Forest Residue Wood Chip Substitution Study

Energy Mines and Resources Canada
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Nova Scotia
Department of Mines and Energy

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FOREST RESIDUE WOOD CHIP SUBSTITUTION STUDY

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SUMMARY AND CONCLUSIONS

Given the current productivity levels of Nova Scotia forests, residues and non utilized biomass are available in large quantities. The harvest and the consumption of this unused biomass is possible and can have significant benefits both in the short term as well as the long term.

1.1 General

The scope and intent of this study was to determine the viability of producing wood chip fuel from forest residue, and identify three consumers and producers, and the costs each group would incur, demonstrating the production and consumption of wood chip fuel produced from forest residues. The findings indicate that a large potential can exist for this new industry if the proper approach to marketing and financing of conversion sites is taken.

2.2 Supply

The five year average of forest production volume in Nova Scotia is currently 3.9×10^6 m^3. This production generates approximately 1,000 kilotonnes of forest residue on an annual basis. This, along with silviculture operations, non commercial stands, and other sources raises this total to over 18,000 kilo-tonnes of biomass that is presently available, an amount that is theoretically equivalent to 33×10^6 barrels of oil. Results of a supplier survey indicate that eight woodlot group ventures, seven large landholders and 32 contractors are interested in the prospect of establishing a residue wood chip business. The skills and resources that exist within this group can guarantee an adequate source of processed residue for those sites interested in burning wood chip fuel.

3.3 The Market

From consumer survey results, 22 of 253 sites canvassed indicated an interest in burning wood chips as fuel. This represents an interest level of 9%. Presently, opportunity exists for growth provided successful demonstration of the technology can be accomplished. Successful demonstration of wood chip burning has already been accomplished in Prince Edward Island and is available for viewing until such time as sites in Nova Scotia are brought on line.

Initially three sites will be studied in Nova Scotia and are as follows:

(a) Sunset Adult Residential Centre - Pugwash

(b) Abco Plastics Division - Mahone Bay

(c) Britex Limited - Bridgetown

The consumption anticipated at each site will average 2,000 green tonnes per year and could displace a total of 8,000 barrels of oil per year.

4.4 Financial Viability and Future of The Industry

Presently three consumers within 80 km of three producers have been identified. It is anticipated that delivered product prices will vary from $30.00 to $65.00 per green tonne at 44% moisture content. At least three consumers for each producer will be required to make a chip production business financially successful. This will only be possible through a series of well orchestrated events. This will involve:

(a) successful production of chips from forest residue

(b) successful demonstration of the handling and burning equipment

(c) an effective marketing campaign

(d) a stable supply and pricing policy.

(e) and finally, subsidies for the chip producer

All of this is possible and the end result can be a new arm of the forest industry creating more jobs, reducing oil consumption costs to the consumer, and displacing significant volumes of oil to the overall benefit of the tax payer.

1.0 INTRODUCTION

As experience in the consumption of forest biomass as a renewable energy source grows, so to does the pressure that is exerted on the current resource.

A recent study [1] commissioned by the Nova Scotia Department of Mines and Energy concludes that sufficient biomass is available in the form of logging residues, non-commercial species, and residuals to provide an adequate source of biomass to the domestic, institutional, and commercial sector users without adversely affecting the supply of wood fibre to the existing forest industry.

Part of the optimism toward forest biomass energy use in Nova Scotia stems from the productivity and strength of its forest industry. Forested lands comprise some 4.1 million hectares of the province's 5.5 million hectare land and water area. Approximately 92 percent of the forested area is considered productive. This land supports one of the economic cornerstones of the province. The gross value of production in the forestry sector exceeds $500 million per year and accounts for over 4% of the Gross Provincial Product. In many rural areas in the Province the forestry industry is the major employer. In 1981, 3,700,000 m^3 of timber were cut in Nova Scotia, providing the raw material for 5 pulp mills and about 370 saw mills.

The Nova Scotia Department of Mines and Energy, in response to the interest expressed by several woodlot cooperatives, and small landholders, has initiated this study to examine the many aspects and potential associated with producing wood chips from forest residues.

To supply wood chips to the consumer on an on-going basis requires an adequate source of raw material supply, proven and efficient production technology, competitive costs, transportation and delivery mechanisms, a full service infrastructure and long term market. Presently only some of these components

are in evidence in Nova Scotia. To effectively develop the rest will require an increase in knowledge on the part of the supplier and producer, and a successful demonstration of both the production and consumption of wood chip fuel.

Thus the objective of this study is to identify the potential suppliers and consumers that fall within a reasonable distance of one another and to identify three prime sites that would adequately demonstrate the technology associated with wood chips as a fuel source.

2.0 STUDY SCOPE AND PARAMETERS

The study has been divided into two phases.

Phase I of the study has been directed at determining the source of residue supply, the amount, the potential suppliers and the potential consumers. Specifically, the following items form the main objectives:

1. Determine the source of residue supply.
2. Determine the amount of residue available.
3. Determine suppliers capable of producing in excess of 1000 green tonnes per year.
4. Determine costs of producing wood chips from residue in increments of 2000 tonnes covering the 1000 to 15,000 tonne range.
5. Determine transportation costs for hauling distances ranging from 15 to 80 kilometres in 5 kilometre increments.
6. Determine potential users within 80 kilometres of an adequate supply of wood chips and having a peak steam demand of 0.6 kg/sec (5000 pph).
7. Identify three prime sites that would adequately demonstrate the equipment and technology associated with burning wood chips.

Phase II of the study deals with an in-depth analysis of the three sites. The objectives of Phase II are stated thus:

1. To produce preliminary designs for wood chip handling, storage, and combustion
2. To produce capital cost estimates
3. To perform an in-depth financial analysis of each site and communicate the findings thereof.

3.0 THE SUPPLY OF RESIDUE

3.1 The Provincial Scene

To determine the amount of residue available within provincial boundaries, an understanding of what constitutes a source of residue must be developed. For the purposes of this study the term "forest residue" is broadly defined to include:.

(a) residue and residuals resulting from commercial logging operations

(b) residue produced from silvicultural operations

(c) non-commercial stands

(d) past logging residues

(e) dead trees and stands

(f) non-commercial species

(g) mill residues

3.1.1 Residues and Residuals Resulting from Commercial Logging Operations

Logging residues are essentially the slash (tops, branches, foliage) and non-merchantable trees left on the harvest site. Components include wood and trees too small or too defective to be merchantable, and trees of non-merchantable species.

Approximately 30,000 hectares of woodland are harvested annually in Nova Scotia. The average wood production over the five year period 1977-81 was 3,910,000 m^3 (1.77 million cords).

In 1982, production fell to 2,700,000 m^3, mainly the result of the Scott Maritime strike and to a certain extent poor world market conditions. However, as the world economy improves, and the forestry sector rebounds, total production volumes will increase to those of pre-1982.

Significant quantities of residue and standing residuals remain on a typical logging site following a conventional commercial harvesting operation. Several research projects have studied and measured such biomass material produced under a wide range of harvesting and stand conditions.[2,10,11,12,13,14,15]

For the purposes of this study, it has been estimated that 900 oven dry kilotonnes of logging residue is produced annually in Nova Scotia. A portion of this residue is merchantable by conventional standards. A recent Lands and Forests study [11] found that 8% of residue left after clearcutting softwood stands was of merchantable size and quality. It is reasonable to assume, that with future wood shortages predicted in Nova Scotia prior to the year 2000, at least a portion of the merchantable residue left on site will be utilized for conventional roundwood products.

3.1.2 Residue Produced from Silviculture Operations

Under the present Forest Resource Development Agreement, many types of silvicultural operations are subsidized in an effort to develop a well managed forest resource. As a result of operations such as cleaning, merchantable thinning, remnant removal, and others, quantities of residue are generated and presently go unutilized. It is estimated that 100 oven dry kilo-tonnes of residue are generated from these operations annually. This

represents a supply of chips that could support up to forty consumers with boilers in the size range of 0.6 kg/sec. (5,000 pph).

In general, residues produced by cleaning and thinning are less readily available and more widely dispersed than residues resulting from harvesting operations (or silviculture treatments such as cutover clearing and remnant removal). These residues would also be found in smaller quantities and would be more costly to obtain.

3.1.3 Non-Commercial Stands

Non-commercial stands are defined as those over 60 years old, less than 40% stocked and which would yield less than 39 m^3 per hectare (7 cords/acre), resulting in a financial loss to the harvesting contractor or woodlot owner, if harvested by conventional means.

These stands are a result of poor forest management in the past, where the best trees were cut and the poor ones left. This type of harvest has been labelled as highgrading.

There are some 400,000 hectares of forest presently in this unproductive condition. This is about 10% of the province's total productive forest land. In terms of biomass, this is equivalent to 6200 oven dry kilotonnes.

As these stands normally do not regenerate adequately, naturally, a program of salvage and planting has been prescribed by Lands and Forests for restoring these sites to productivity (5). Whole tree chipping for fuel would greatly facilitate reforestation, by effectively preparing the site for planting.

The end result of a salvage and reforestation program in non-commercial stands, would be the establishment of a future commercial resource, one that would benefit the forest industry as a whole and further demonstrate the objective of a totally managed resource.

3.1.4 Past Logging Residues

Residues that are presently available from past harvests are those that are not covered or obscured by new growth as well as the usual standing residuals. For the purposes of this study, three years was the time span considered for the estimate of residues. This was felt to be a reasonable period of time on which to base residue projections and would probably not result in new costs for access roads and landing preparation.

A total of approximately 2000 oven dry kilotonnes of biomass are available in the form of past logging residues.

3.1.5 Residue From Dead Trees and Stands

Tree mortality caused by a prolonged spruce budworm infestation is the source of forest residue considered in this category. As a result of the latest budworm epidemic, 24,000,000 m^3 of softwood in Cape Breton and Cumberland County has been lost (ie. killed or not feasible to harvest due to low volume and or poor quality). Some of the dead stands have been salvaged. Between 1978 and 1982 about 3,400,000 m^3 of wood was salvaged from the Cape Breton Highlands, and a much smaller salvage program was undertaken in Cumberland County. Further opportunities to use large volumes for conventional products are limited by the annual industrial capacity of plants and the poor quality of such wood.

Once tree mortality begins the maximum length of time available for a normal commercial harvest is approximately seven years.

It is estimated that 6000 oven dry kilotonnes of budworm kill is presently available in the forest. Although it is a short term supply, the quantities available are indeed significant and could displace large quantities of oil if markets were in place. No attempt has been made to estimate further, volumes of dead trees due to the effects of other insects, disease, fire, or wind, but it is felt that considerable biomass is present in this form.

3.1.6 Unutilized Species

Presently, several species of trees that exist in Nova Scotia are considered to be of little commercial value as there is no established market. Examples of these would be aspen, grey birch, beech and others. A conservative estimate of the volume of such species is ten percent of the province's hardwood resource. A total assessment of this resource has been calculated for this study and suggests 3000 oven dry kilo tonnes are presently available.

3.1.7 Sawmill Residue

Sawmill residue takes many forms. Basically it is comprised of bark, slabwood, sawdust, chips and shavings as a result of normal sawmill operations. In a recent study [1] it was determined 36 kilotonnes of sawmill residue are currently unused. With this material readily available near roadside, costs of this energy source are generally quite low. However, it has been determined that all manufactured chips are sold as pulp chips and little if any would be left for fuel consumption. Most of the remaining residue is dispersed throughout the province and some is used in agricultural

applications. Therefore, it might be concluded that in the absence of fuel preparation facilities and because of geographical disbursement this source of residue may go unused unless existing markets for bark, shavings, and sawdust are expanded.

3.1.8 Summary

To summarize the resource, it is presently seen to be comprised of six main components. Residue and standing residuals left as a result of a normal commercial harvest, yields from silviculture operations, non-commercial stands, past logging, budworm damaged stands, and unutilized species. Table 1 illustrates the total quantities of such residues presently available in Nova Scotia. The assumptions used in arriving at these estimates are found in Appendix 2.

No attempt has been made to estimate what portions of the residue resource may be economically recoverable. Some of the more important factors which influence the economic recovery of this material are:

- volume per hectare
- geography
- harvesting and processing equipment and methods
- market price
- conventional product utilization standards

The demand and quality requirements of the pulp and paper industry are normally quite stable. Fluctuations, however, can occur and should the quality requirements rise or the quantity requirements fall, significant quantities of biomass suitable for wood chips can result.

In summary, one thing is clear, a large potential resource exists and can be utilized, only if sufficient markets can be established. Establishment of a wood chip fuel industry will allow a presently wasted resource to be utilized and, if successful, displace large quantities of imported oil.

TABLE 1

Provincial Summary of Residues

Source		Oven Dry Kilotonnes/Year	Total Available Oven Dry Kilotonnes
1.	Logging Residue and Residuals From Commercial Harvests	900	
2.	Residue from Silvicultural Operations (Cleaning, Thinning, Other)	100	
3.	Non-commercial Stands		6,000
4.	Past Logging		2,000
5.	Budworm Damage		6,000
6.	Unutilized Species		3,000
	TOTAL	1000	17,000

NOTE: 1. See Appendix 2 for list of assumptions

2. Tabulation of residue from 3 to 6 are intended to show the total resource presently available. Annual harvests of these classifications will be dependent on market conditions.

3.2 Volume of Commercial Harvest Residue by Ownership Class

Relying on five year production figures quoted in the 1983 Submission to the Royal Commission on Forestry by Nova Scotia Lands and Forests, it can be seen that of total roundwood production reported 23% is produced on Crown land, 37% by large private owners, and 40% by small private owners who by definition own less than 1000 acres.

In examining the amount of residue that result from commercial harvest operations it can been seen that small private landholders are indeed a large contributor on the provincial scene and could benefit from a residue wood chip industry if sufficient markets can be created. Table 3 illustrates the amount of residue that can be produced by the various land holder classifications.

TABLE 2

Commercial Harvest Residue Production
By Ownership Class

Source	Average Volume 1977-1981 Production		1000 Bone Dry Tonnes
Provincial Crown	899,300 m^3	23%	200
Large Private	1,446,700 m^3	37%	300
Small Private	1,564,000 m^3	40%	400
TOTAL	3,910,000	100%	900

Based on 1977-1981 production average in Nova Scotia.

NOTE: 1. See Appendices 2 and 7 for assumptions and data

3.3 Group Ventures As a Source of Supply

3.3.1 Background

In the past number of years, group ventures have come into existence as a result of two influences. One influence was the concern of a large number of private woodlot owners who wanted to expand the production capability of their resource. The other influence was the Provincial and Federal governments who wanted to see a resource better managed and capable of meeting future demands. The most recent program in support of these influences became effective in August of 1982 and has become known as the Forest Resource Development Agreement.

Through various agreements in the past and in conjunction with the most recent FRDA, several group ventures representing five to six hundred private woodlot owners have come into existence. As well, present trends indicate more may establish in the future. The goal of these group ventures is to: a) manage and plan their resources better and, b) to become self-sustaining both as management groups and as business entities. With these goals in mind it is clear that these woodlot co-operatives represent an excellent choice as supplier given favourable market conditions.

3.3.2 Supply Resource of the Group Ventures

Presently, eight woodlot group ventures are registered under the FRDA program. These group ventures represent holdings in excess of 35,500 hectares, have forest management plans in place and employ qualified managers and foresters. Presently market conditions vary considerably and in the case of some group ventures production is very low. Table 3 illustrates current holdings, the level of production, residue, and non-commercial biomass availability.

TABLE 3

Summary of Group Ventures
Activity and Residue Potential

Group	(1) Holdings ha	(2) A.A.C. ODT/yr	(3) Commercial Production ODT/Yr	(4) Logging Residue ODT/Yr	(5) Potential Logging Residue Based on AAC ODT/yr	(6) Estimated Non Commercial ODT Biomass/Yr	(7) Silviculture Residue ODT/Yr
West Pictou	5,300	5,600	2,100	1,300	3,400	1,100	500
Baddeck	5,000	3,900	2,900	1,800	2,400	4,000	1,200
North Nova	5,700	9,000	1,000	600	5,500	1,100	N/A
La Foret	2,500	9,000	1,000	600	5,500	—	1,600
North Mountain	2,400	1,700	1,300	800	1,000	300	400
Sissiboo	4,600	2,200	500	300	1,300	1,100	1,400
Conform	5,000	5,600	3,000	1,800	3,400	3,400	2,500
Athol	5,000	5,000	1,300	800	3,000	—	1,500
TOTAL	35,500	42,000	13,100	8,000	25,500	11,000	9,100

NOTE: 1) Columns 1, 2, 3, and 6 : based on questionnaire responses.

2) Columns 4 and 5: logging residue estimates based on assumptions in Appendix 2.

3) Column 7: based on 5 year management plan summaries proposed for Group Ventures and/or residue estimates by Wiksten (1977), Neill and Gunter Limited and Atlantic Forestry Consultants.

Clearly, group ventures have a significant level of residue and non commercial biomass available. If 2,000 green tonnes of chips per year is used as an approximate consumer requirement then each group venture has the capacity to support a minimum of one site in all cases and possibly up to four, depending on the market and any production restraints that may be imposed.

3.3.3 Level of Interest and Production Capability

To determine the levels of interest, group ventures were contacted on a personal basis and by mailed questionnaire. Not surprisingly, the interest expressed is very high. All eight of the co-operatives have expressed a high degree of interest and willingness to explore chip production further. Presently, most group ventures have an under utilized resource and in some instances large areas of dead or non-merchantable stands. It is clear that given the markets these group ventures would respond in a positive manner and establish themselves as chip producers. With the present level of activity within the group ventures and given the small nature of individual holdings it would seem logical that the group ventures would have two alternatives to assess in establishing themselves as producers. The key component that has to be added is of course the chipper. The two options that are available are:

(a) rental of the chipper from a contractor and

(b) purchase of a chipper for use by all members of the group venture

Provided the economic hurdles can be overcome, these co-operatives would be an excellent source of supply, and given the markets, can demonstrate their ability as long term producers. The Southern New Brunswick Woodlot Co-op has already demonstrated its ability as a whole tree chip producer and has recently secured a three year contract for supply of chips to a school. Given this as an example, no reason exists why Nova Scotia group ventures cannot establish themselves in a similar manner.

3.4 Large Private Landholders as a Source of Supply

3.4.1 Background

Large private landholders are those whose holdings are in excess of 400 hectares. In Nova Scotia approximately 991,000 hectares are controlled by 189 large land holders.

Given the level of contribution these large landholders make to annual production it is clear that sufficient quantities of residue are generated to displace many barrels of oil. Of the 189 large landholders four are major pulp and paper companies.

The holdings of the pulp and paper group total 690,860 hectares which represents seventy percent of the large land holdings. This group as a whole is very interested in methods that would eliminate wood residues and slash from their holdings. With the pressures being exerted by the annual harvest and budworm, an elimination of costs associated with preparing the site for planting would be welcomed. Clearly, if a market could be established, the co-operation of this group could be assured. Presently three of the four companies are examining chip production from residues and residuals and one company is already producing chips for boiler fuel on a large scale.

3.4.2 Supply Resource of the Large Private Landholders

Table 2 illustrates that 400 kilo-tonnes of residue are available for harvesting as a result of the annual commercial harvest. It again is no surprise that large quantities are available and theoretically capable of displacing large volumes of oil. Development of a market for these large quantities is necessary if this material is to be removed and may only be possible through intensive marketing campaigns.

3.4.3 Level of Interest and Production Capability

For the purposes of this study it was felt that in order to produce 1,000 green tonnes of chips per year from residue and residuals, a minimum holding of 2,000 hectares would be required. Forty-one questionnaires were issued representing a coverage in excess of 861,000 hectares. This translates to 87% of the holdings and was deemed to be representative of the group. Seven of the forty holders surveyed responded which in terms of hectares represents 70% of the holdings.

Interest in the pulp and paper sector is very high. Nova Scotia Pulp Limited is already producing chips on a large scale for a recently commissioned boiler. Minas Basin Pulp and Power have recently completed studies that examined the production and burning of chips and have made formal presentations to their board of directors for consideration. Scott Maritimes and Bowater Mersey Ltd. have qualified their positive interest by relating their interest to a supportive market and would probably be willing to spend the necessary capital provided a large enough market could be developed.

Of the other private holders three respondents indicated they would be willing to enter into contracts with either rented or purchased production machinery depending on market conditions.

Production capability of this group would not be a question. With harvesting systems currently in place little by way of equipment would need to be added. A chipper is all that would be required initially if the product were to go straight from the forests to the consumer.

3.5 Small Private Landholders as a Source of Supply

The holdings of this group are those that contain less than 400 hectares. As the large majority of holdings of this group vary from 20 to 100 hectares and are not capable of producing 1000 green tonnes of chips per year it was felt that responses from individuals would not be meaningful. The survey of the woodlot co-operatives was deemed more representative of the group and interest as stated previously was very high. Because this group contributes forty percent to the annual harvest there can be no question that they have a potential to produce large volumes of chips. Through the co-operatives, private contractors, and purchase of small chippers for individual use this group can establish themselves as producers as the markets develop and grow.

3.6 Provincial Crown Land as a Source of Supply

Approximately 1,000,000 hectares of forest land, roughly 24% of total forest land in Nova Scotia, is Crown Land which is under the administration and control of the Department of Lands and Forests. Most of this land is in forest production, and although various licensing agreements are in effect with pulp and paper companies and sawmills, the Province has control over forest management activities. Day to day, forest

operations are managed by the license holders. Some crown land is also managed directly by the Department of Lands and Forests.

As the level of forest management activity is quite high on Crown Lands, it is felt that residue for such land would contribute significantly to the provincial supply.

Table 2 has indicated 200 kilotonnes of residue is generated on Crown Land accounting for 23% of the annual production. It is assumed this amount of biomass is available on a continuing basis.

3.7 Supplier Survey

To determine the amount of interest that currently exists in Nova Scotia from suppliers interested in producing chips from forest residue, a questionnaire was compiled and sent to all registered wood lot cooperatives, land owners, with holdings in excess of 2000 hectares, silviculture contractors and pulpwood contractors. A total of 158 questionnaires were mailed and 32 individuals or companies responded favourably. This represents 20% of those canvassed and speaks well for the interest that is currently in place. A map of User/Supplier Groups has been prepared and included under Appendix 1.

Also included is a list of the group ventures, private landholders, and pulp and silviculture contractors interested in supplying wood chips. In conjunction with this, another list has been prepared showing the potential customers.

4.0 HARVESTING, PRODUCTION METHODS AND COSTS

4.1 Background

In order to determine what might be the best approach to harvesting residues, residuals and other biomass material, a contractor must fully be aware of the task at hand. Several studies have been funded under the Enfor program and have yielded excellent results in some cases. Much of the information on production methods and rates has been reviewed and gleaned from References 4, 12, 14, and 15 and form the basis for the discussions that follow. These reports which deal with the costs and production of biomass are recommended reading for any individual or group contemplating chip production.

4.2 Selection of Equipment

For the purposes of the discussions that follow the choice and amount of equipment chosen are based on the premise of necessity and demonstration of an efficient harvest system.

The market, the type of stand, and present equipment inventory will dictate final equipment selection. For the production analysis that follows several vehicles are considered. They are a medium sized wheeled skidder, large wheeled skidder, a small wheeled forwarder, and a feller forwarder.

Medium Skidder - is a rubber tired vehicle complete with 55 kw (75 HP) power plant, winch, and chokers and is run by one operator. This machine drags or skids pieces or bunches of varying lengths and sizes to a designated landing area.

Large Skidder - description is similar to the Medium Skidder except the power plant is greater than 55 kw (75 HP) and is generally capable of skidding larger loads. Power plants can range in excess of 150 kw (200 HP). Production rates can be expected to vary.

Small Forwarder - is a rubber tired vehicle complete with an articulated, frame steered, four wheel drive chasis and is capable of transporting the material on an attached bunk to a landing.

Feller Forwarder - is a large harvesting machine capable of grappling trees, shearing them at the base, placing them full length on an attached trailing storage bunk, transporting the product to the the landing and dumping the load. This type of machine has very high production rates which vary with geography and stand configuration.

This equipment with the exception of a small tractor and dumping trailer that might be considered for a very small woodlot is generally what is available and operating in various areas of the province. As part of an integrated operation an established contractor will have a simple choice: He will apply his existing equipment to this new area of harvest and apply the most efficient means of biomass gathering available.

4.3 Harvest Options

4.3.1 Feller-Forwarder

Because of the large amounts of capital required to invest in a totally mechanized operation it is unlikely that most individuals or groups would be able to support such an operation initially. The equipment requirements for this operation include a feller forwarder, a 15"-22" chipper, chip vans and two operators. This operation is best applied to harvesting of standing residuals and low grade or non commercial stands. Productivity rates appear to be the highest for this combination of equipment. As reported by Wiksten and Prins, 1980, a feller forwarder may be expected to produce 4.34 ODT/hr or approximately 7.75 green tonnes/hr. Capital requirement for new equipment is approximately $470,000.

4.3.2 Feller Buncher and Skidder

This combination of equipment is one that has proved quite productive for one contractor in Prince Edward Island. Jim Hornby reports that with this combination of equipment his peak production when harvesting non-commercial stands amounted to 85 green tonnes per day and averaged 52 tonnes per day. It was also reported that this was lower than could normally be expected due to losing a clutch on the feller buncher twice at a cost of three days productivity each time. Because Mr. Hornby's contract to supply chips to the Montague Hospital is limited to 2000 tonnes per year the Feller Buncher was leased which indicates that production costs could be much lower than those realized if a full scale operation were warranted. The equipment for this option is a feller buncher, skidder, truck mounted grapple, and chipper with three operators being required. This equipment operation is best applied to low grade stands and standing residuals. Average production on this operation was 6.5 green tonnes per hour or 4.76 ODT per hour. This selection of equipment at new equipment prices costs approximately $400,000.

4.3.3 Skidders and Chain Saws

a) Harvest of Residuals and Non Commercial Stands

A combination of skidders and chain saws for felling is one of the most common combination that will be used. This combination of manpower and machinery lends itself reasonably well to harvesting low grade stands and standing residuals.

The equipment requirements for this operation are two chain saws, two skidders, one chipper, and five crew members. Productivity on the Prince Edward Island harvest averaged about 4.8 green tonnes per hour or 2.68 ODT/hr. This agreed very closely with Wiksten and Prins who reported production of 2.38 ODT/hr for a large skidder harvesting residual trees and non commercial stands. Capital investment required for new equipment would probably amount to $250,000.00.

b) Harvest of Residues Only

Average productivity expected when harvesting logging residues only, is lower. Wiksten and Prins, 1980 reported estimated productivities for eight harvest areas. Using large skidders, results varied from 1.21 to 3.37 ODT/hr for modified manual bunching and averaged 2.0 ODT/hr. Where modified manual bunching was not used production was drastically lower varying from 0.36 to 1.71 ODT/hr and averaging only 0.80 ODT/hr. Modified manual bunching would require additional labour to gather the light pieces and stock them in bunches with a view to increasing skidder productivity. This method would lend itself well in areas where there were a high number of small pieces. It is clear from this analysis that modified manual bunching is the most productive means of harvesting residues with this particular combination of equipment. Two additional labourers are required to assist with the bunching but appears to be justified when production is doubled.

4.3.4 Small Forwarders and Chain Saws

A combination of small forwarders and chain saws for felling is an excellent choice of equipment for harvesting logging residuals and residues. Depending on the size of the forwarder, standing residuals or non commercial stands once felled could be cut into lengths and forwarded to the landing. No production figures are available for this option but it would appear to be a viable alternative. In the harvest of logging residue only Wiksten and Prins, 1980 report that in combination with modified bunching, production rates of the small forwarder are quite good. Rates varied from 2.01 to 3.56 ODT/hr and averaged 2.57 ODT/hr as opposed to an average of 1.05 ODT/hr without manual modified bunching. A modification to this approach would be the addition of a trailer to the forwarder. Unfortunately no production data is available but it would appear to be an attractive alternative as well.

Equipment requirements here might be two forwarders, two chain saws and one chipper with a total crew of five. Capital investment for new equipment would be in the order of $280,000. Additional funds for a large heavy duty trailer might be $25,000.

4.3.5 Small Woodlot Harvest Operations

Harvest operations in small woodlots by their nature lend themselves to an integrated operation. Production of chips from tops and limbs is readily accomplished when whole tree, full tree, or tree length methods are used in combination with a tractor and winch operation. The quantity of chips produced from residue will vary and unfortunately, no information on production rates and costs are available. A group of forestry specialists at the University of

New Brunswick have recently run production trials on non-commercial stands employing a tractor, PTO chipper, and Farmi winch. As reported by C. A. Short, the cost per tonne of chips at 20% moisture content worked out to $140 to $180 per tonne (20% M. C. basis). The labour costs associated with this trial approximately equals 50% of the total. The hourly cost of labour on this project was $7.40. Mr. Short felt that unless the small woodlot operator was willing to work for zero wages that this method of chip production was not economically feasible. Various methods of harvest for the small woodlot operators are described in Appendix 7 and have been reproduced from a federally commissioned study [16] with the kind permission of Dr. S. M. Pneumaticos.

Equipment for the various methods described generally consists of a tractor, a winch, a delimbing device and power take-off chipper. Small PTO chippers suitable for a tractor operation are available at a cost of $6,000-$11,000. The maximum tree size that could be processed would be approximately 150 mm (6 inches) to 250 mm (10 inches).

For collection of logging residue, a PTO mounted chipper with a trailing forage wagon complete with a live bottom could be utilized. Cost of the forage wagon would be approximately $6,000 and the tractor would be $18,000 depending on size selected. No production rates are available for logging residue collection by this method, but it is felt that they would be quite low compared to other harvest systems. In addition to this a forage or chip blower would be required to blow the chips to a delivery truck or to storage, this depending on the frequency of the harvest and the volumes gen-

erated. Interim storage is probably required so that sufficient volumes can be accumulated for delivery truck loading. Production rates for this method may average 0.7 ODT/hr when harvesting low grade stands.

4.3.6 Skidder Mounted Slash Rake

A recently completed report [4] concluded that the harvesting and chipping of logging residues following a tree length harvest operation in Northern Ontario was economically feasible. A skidder mounted slash rake was used to windrow dried slash. The concentrated material was then chipped on the site by a mid-sized chipper mounted on the pulp bunk of a small forwarder. The chipper was fed via a specially-made infeed conveyor which was loaded by the forwarders grapple. A forage wagon, pulled along by the mobile chipping unit, was used to transport the chips to a landing where they were blown into highway chip vans. Production figures for this report indicate 3.15 ODT/hr can be harvested by this method. The author concluded that probable production with equipment improvements and a fully experienced crew would be about 5.0 ODT/hr. Capital investment for an operation of this type would be approximately $205,000.

4.3.7 Harvest Summary and Expected Productivities

The final method of residue and residual harvest chosen will depend on many factors. For the most part it will be dictated by present equipment inventories and it will be up to the individual to choose the most appropriate combination from his selection of equipment. Table 4 presents expected production rates for the various methods previously described.

TABLE 4

Harvest Methods and Expected Productivity

	Harvest Method	Stand Type	Output ODT/hr Non Bunching	Average Output Manual Modified Bunching
1.	Feller-Forwarder	Standing Residuals Non Commercial Stands	4.34	—
2.	Feller Buncher & Skidder	Standing Residuals Non Commercial Stands	3.64	—
3.	Skidder & Chain Saws	Standing Residuals	2.38 (Large) 1.71 (Medium)	— —
4.	Tractor & Chain Saws	a) Thinnings and Standing Residuals	1.0	—
		b) Non Commercial Stands	1.0-2.0	—
5.	Skidders & Chain Saws	Residue Only	0.80 (Large) 0.70 (Medium)	2.0 (Large) 1.25 (Medium)
6.	Skidder & Slash Rake	Residue Only	3.15	—
7.	Small Forwarder & Chain Saws	Residue Only	1.05	2.57

It is clear that for harvesting standing residuals or low-grade (non commercial) stands the feller-forwarder and feller buncher + skidder were the most productive methods.

The skidder + slash rake appears to be the most productive method of producing chips from logging residue (slash). It is worthy to note, however, that although no production figures are available, it is felt that a small forwarder + wide trailer combined with manual modified bunching would achieve comparable production rates. Another alternative would be a combination of the two methods, i.e. pile residue with slash rake and collect with forwarder and trailer.

No data is available on this option but it appears to be an attractive alternative and one that should be considered by individuals wishing to maximize production.

To examine the differences between expected and actual results that have been obtained in harvesting trials Table 5 illustrates productivities that have been achieved in actual trials.

TABLE 5

	Location	Stand Description	Harvest Method	Average Productivity Green Tonnes/Hr	ODT/Hr
1.	Bowater Newfoundland	Residual Hardwood	Chain Saws & Skidders	4.2	2.35
2.	Abitibi Price				
	a) Stoney Brook	(3314 Stems/Ha) Small Diameter White Birch	Chain Saws & Skidders	3.3	1.8
	b) Little Rattling Brook	(2943 Stems/Ha) Fire Killed Spruce	Chain Saws & Skidders	1.9	1.1
	c) Exploits River	(1214 Stems/Ha) Mature White Birch	Chain Saws & Skidders	6.8	3.8
3.	a) J. Hornby P.E.I.	Non Commercial Stands	Chain Saws & Skidders	6.0	3.4
	b) J. Hornby P.E.I.	Non Commercial Stands	Feller Buncher & Skidder	6.5	3.64
4.	Northern Ontario (E. David)	Residue	Skidder & Slash Rake	5.6	3.15

NOTE: 1) No information on Residue Harvest Only has been located.

2) Average production was low in 3 (b) due to equipment malfunction. Peak production was reported at 10.6 green tonnes/hr.

4.4 Chipper Selection and Productions

One of the most crucial decisions in the establishment of a wood chip fuel business will involve the selection of the chipper. Because of the high costs that are associated with the large chippers the proprietor has to be careful not to allow monthly operating costs to become too large or the economics of the operation will be upset.

Cost of the chipper is directly related to the diameter of the tree it can process. In a strict residue harvest operation where only tops and limbs are gathered a very small chipper would probably suffice. However, this must be directly related to the method of harvest as one small chipper operating in sequence with harvesting equipment could become a point of constriction in the production sequence. There are a wide range of sizes available but for the intent of this study will be confined to a maximum size of 450 mm (18 inches). The ranges and approximate prices are shown in Table 6.

TABLE 6

Chipper Size Range and Prices

Chipper Size	Chipper Price
150 mm (6 inch)	$ 7,000
250 mm (10 inch)	$ 10,000
300 mm (12 inch)	$ 16,000
350 mm (14 inch)	$ 65,000
450 mm (18 inch)	$100,000

In a residue harvest operation assuming gathering of the material doesn't greatly exceed the production capability of the chipper, a power take model chipper in the 150 to 250 mm (6 to 10 inch) size range will handle ninety percent of anitcipated residues. In a harvest of standing residuals or low grade stands the 300 to 450 mm (12 to 18 inch) size range will be required. There is a major price change once the 300 mm (12 inch) size is passed. Matching economics and the appropriate equipment to the job are important considerations. In a year round operation it would seem appropriate to choose the larger model chipper because of greater durability and less downtime for maintenance. In a part time operation where only small volumes are expected it would seem appropriate to select the lighter duty and lower priced options. Any material in excess of chipper capacity could either be left as future nutrients or if volumes are sufficient harvested for pulp or fuel wood.

Production rates will vary with the chipper chosen. It is anticipated that for most harvest operations the chipper capacity will not be a restraint but in fact be controlled by the harvest method. It is felt that most chippers should be equipped with grapples to avoid delays associated with extracting material from tangled windrows or piles. Some of the larger chippers come complete with grapple while some of the smaller ones do not. A truck or tractor mounted grapple is an option and one that is currently employed by one chip contractor on Prince Edward Island.

Chip quality is directly related to the sharpness of the knives. Longer intervals between knife changes will be possible if the material is conveyed to the landing by forwarders. If the majority of material is skidded knife changes can be expected to be more frequent and increase by a factor of three or four.

Production rates for a 350 mm (14 inch) chipper can be expected to average approximately 6 ODT/hr when whole tree chipping residuals and non commercial stands and approximately 3 ODT/hr when chipping residues [12]. This observation is borne out by production rates quoted by Mr. Jim Hornby of Prince Edward Island who operates an eighteen inch chipper and appears to be a fair representation of productivity for equipment of this size range. A 250 mm (10 inch) power take off operated unit is estimated to be able to produce chips at a rate of 0.8 to 1.0 ODT/hr when chipping whole trees and 0.4 to 0.7 ODT/hr when chipping residues.

Production costs for chipping can be expected to vary but as an average will cost about $6.00 to $6.50 per green tonne.

4.5 Summary of Roadside Production Costs

To see the differences harvest methods have on costs Table 7 has been prepared. The roadside cost per green tonne and per oven dry tonne have been calculated. For a full list of governing parameters please refer to Appendix 4.

TABLE 7

Costs of Wood Chips From Residues and Residuals

	Harvest Method	Stand Type	Cost/Green Tonne @ Roadside	Cost/ODT At Roadside	Comment
1.	Feller Forwarder	Standing Residuals & Non Commercial Stands	$13.12	$23.42	Note 5
2.	Feller Buncher & Skidder	Non Commercial Stands	a) $27.84 b) $17.03	$49.71 $30.41	See note 2 See note 3
3.	Skidders & Chain Saws	Non Commercial Stands	a) $25.08 b) $20.95	$44.78 $37.41	See note 2 Note 5
4.	Tractor & Chain Saws	Non Commercial Stands	$33.14	$59.17	Based on Avg. 0.7 ODT/hr
5.	Tractor & Chain Saws	Residue Only	----	----	No Data Available
6.	Skidders & Chain Saws	Residue Only	a) $28.67 b) $51.19	$51.20 $91.42	Bunching (5) No Bunching (5)
7.	Skidder & Slash Rake	Residue Only	---- ----	$44.05 $28.05*	See note 4
8.	Forwarders	Residue Only	$16.21	$28.95	See note 5

NOTE:

1. Costs for Skidders assume medium size.
2. Costs for J. Hornby's operation were estimated by Neill and Gunter Limited and Atlantic Forestry Consultants.
3. Production costs are expected to be lower on a continuous operation.
4. E. David estimates an experienced crew can lower production costs to $28.05/ODT.
5. Costs are estimated and pro-rated to present day values by Neill and Gunter Limited and Atlantic Forestry Consultants from Enfor report P-19.

4.6 Establishing a Price For Wood Chips

An examination of Table 7 reveals a wide range of methods and resulting production costs. To develop a range of costs for productions varying from 1,000 to 15,000 green tonnes a base price of $26.00/green tonne at roadside has been used. This is an average cost of all methods displayed in Table 7. Based on responses from the contractor survey half indicated use of porters as the most common means of extraction and the other half used skidders. This clearly states the need for a range of prices to suit individual needs.

As well investigation of the existing contracts must play a role in determining average industry prices. One established contract in Prince Edward Island states a price of $30.00/green tonne at 42% moisture content (wet basis) delivered, and one in New Brunswick to commence in the fall of 1983 stipulates a price of $27.94/green tonne at 42% moisture content (wet basis) delivered. Subtracting transportation costs yields a price of approximately $23.00/green tonne which is close to the average costs in Table 7. Prices displayed in Table 7 assume continuous production and make no allowance for carrying costs of chippers, storage buildings or delivery trucks. Initially at low market demands it is assumed only one site will be available and consume in the order of 2,000 tonnes of chips per year. The predominant costs to carry for a new operation is that of the chipper and chip storage facilities. The costs displayed in Table 8 show the effects of interest charges and storage costs.

TABLE 8

Production Volumes And Costs
At Road Side
Effects of Financing, Storage, and Subsidies

Production Green Tonnes	Base Cost Avg.of All Methods	Equipment Financing	Storage	Total Cost
1,000	26.00	40.58	4.80	71.38
2,000	26.00	17.59	2.08	44.17
4,000	26.00	7.45	0.88	32.88
6,000	26.00	4.06	0.48	29.04
8,000	26.00	2.37	0.28	27.15
10,000	26.00	1.35	0.16	26.01
12,000	26.00	0.68	0.08	25.26
14,000	26.00	0.20	0.02	24.72
15,000	26.00	0.00	0.00	24.50

NOTE: 1) Financing charges are based on a 14" chipper valued at $65,000. Lower charges can be obtained for lower priced equipment.

Rental of a pole barn or similar structure will add to the cost per tonne but like financing costs will have a decreasing effect as production rates increase.

Clearly a wide range of prices are possible, all interdependent on stand and residue density, harvest technique, efficiency of the operation, financing, storage charges and so on. It will be incumbent on the producer to manage these variables so as to create a product with an attractive price. Matching chip prices to levels that are near or below the world oil price is not sufficient. The customer must have sufficient return on investment levels in order to consider converting his boilers to wood chips and must have some guarantee on stability of pricing and supply. As experience and confidence in this energy source grows so to does the potential. An efficient and well managed approach is necessary to guard against overpricing. Competitive costs are an essential element if future markets are to grow.

4.7 Transportation Methods and Costs

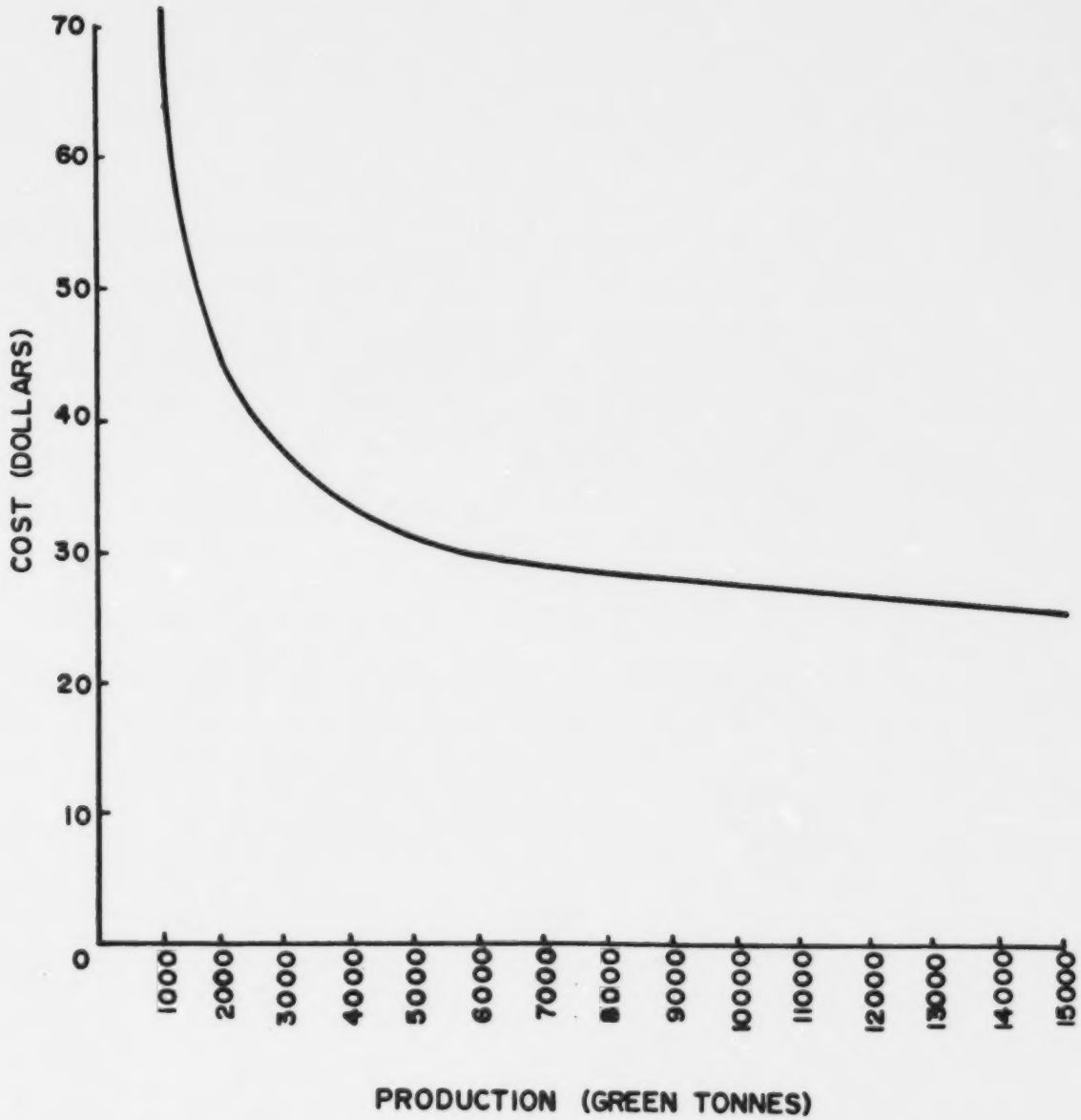
There are several modes of transportation currently available that are suitable for delivery of chipped wood fuel. The most efficient is the large tractor trailer that can haul up to twenty-six tonnes of chips. The next most efficient option would be the use of a trailing dump truck with built up sides and capacity of 12 to 15 tonnes per load.

The remaining option is that of a tandem dump truck with built up sides or attached container. These vehicles can transport 9 to 10 tonnes per load and are reasonably efficient over short haul distances.

For delivery of large loads to a central storage facility use of the large tractor trailer chip vans is recommended. More space is required on the landing and roads must be in good condition but the cost savings make this worthwhile. An increased cost of approximately forty percent would be applied to

FIGURE 1

TYPICAL PRODUCTION COST CURVE



make use of smaller tandem dumps on a haul of 50 km. For delivery to a customer with a small storage bin a small tandem may be the best method. The successful supplier will eventually have to determine what the most efficient delivery mechanism is and adjust this aspect of the operation accordingly.

Table 9 that follows displays the average cost for wood chip haulage presently in place in Nova Scotia. The prices shown are not related to any individaul or company but are presented as a current industry average. The rates also reflect the current transportation subsidy of ten percent available to non-owner operators.

TABLE 9

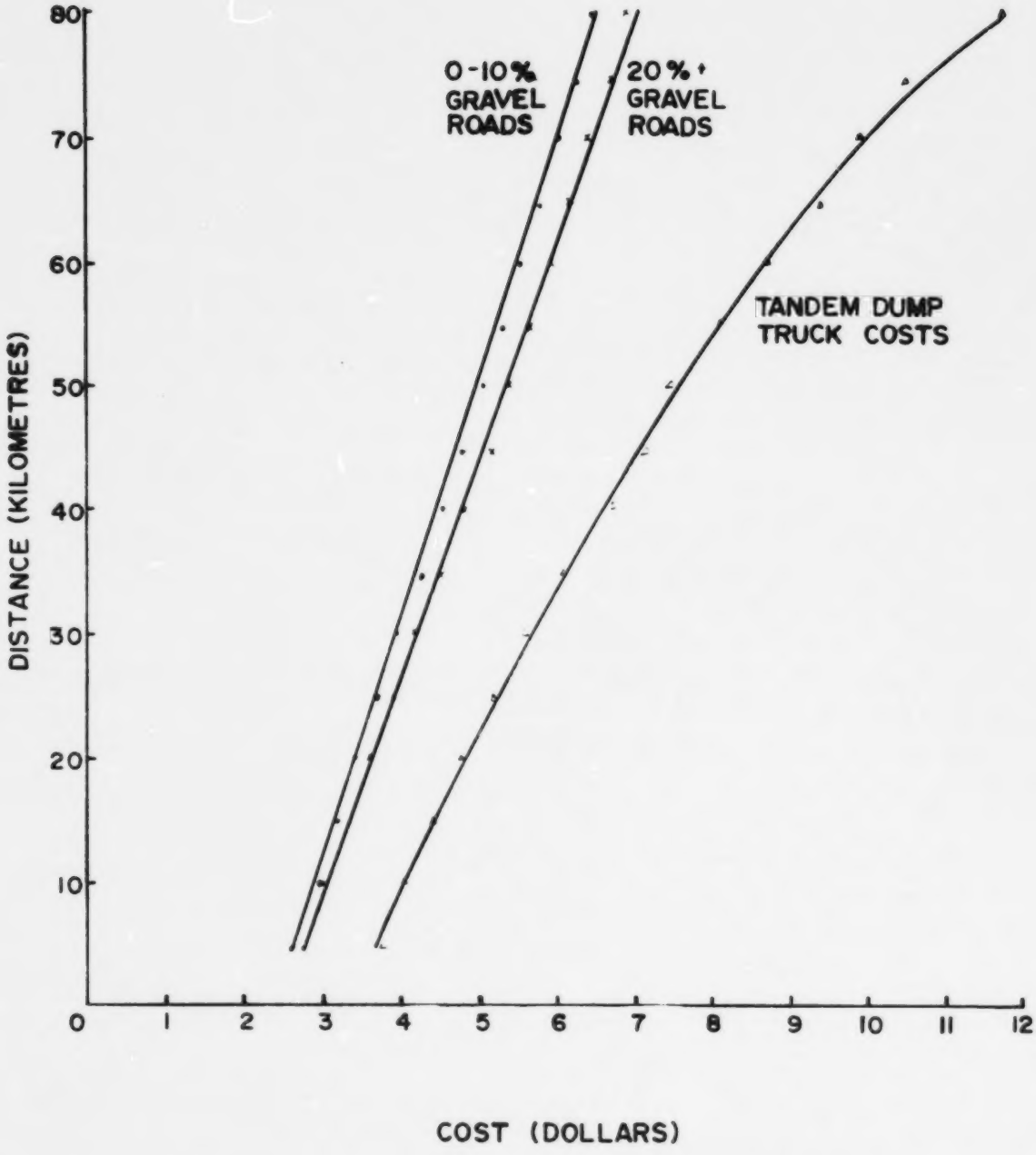
Chip Transportation Costs

Distance	% Gravel Roads		
	0-10	10-20	20% +
0-5	2.69	2.71	2.73
5-10	2.90	2.94	2.99
10-15	3.17	3.22	3.27
15-20	3.44	3.54	3.61
20-25	3.72	3.82	3.90
25-30	3.98	4.10	4.21
30-35	4.27	4.39	4.51
35-40	4.53	4.67	4.81
40-45	4.79	4.95	5.11
45-50	5.05	5.19	5.33
50-55	5.30	5.47	5.64
55-60	5.55	5.74	5.93
60-65	5.79	5.98	6.16
65-70	6.02	6.23	6.42
70-75	6.24	6.47	6.70
75-80	6.47	6.72	6.98

Figure 2 depicts the effects that distance have on these rates and also give an indication of prices associated with hauling chips by tandem dump truck.

FIGURE 2

TRANSPORTATION COST CURVE



4.8 Delivered Price of Wood Chip Fuel

Based on the information in Table 8 and Table 9 it would appear a contractor could produce and deliver chips 80 km for a contract price of $30 to $65 per green tonne for an initial production quantity of 2,000 green tonnes and no subsidy. As the markets grow and efficient operations are developed this price could be expected to stabilize in the $30 to $35 per green tonne range and remain stable with the exception of inflationary pressures. If subsidies can be applied to the larger volumes then a low cost wood chip fuel will be the result. This would bring the net costs of the operation down significantly and could result in a modest profit for the producer. Assuming an operating efficiency of 80% on oil burning and 60% on wood burning one green tonne of chips at (4855 BTU/lb) would equal approximately 1.13 barrels of oil. The equivalent price based on a current price level of $43.00 per barrel would be $48.59. As boiler efficiencies increase so to does the equivalent costs. In a recent burn test Abiti Price obtained results that yielded one green tonne of chips at 39.9% moisture equalling 1.49 barrels of oil [15]. The boiler efficiency in this case was 76.3%. The equivalent price at today prices would yield one green tonne of chips valued at $64.00. So depending on the moisture content and boiler efficiencies the value of this product can rise substantially yielding acceptable rates of return for the consumer and guaranteeing a long term market for the producer.

5.0 THE MARKET, IDENTIFICATION OF CONSUMERS, AND LONG TERM BENEFITS

5.1 Consumer Survey Method and Site Selection

To determine possible candidates for a demonstration site a list of institutions including hospitals, school boards, municipalities, and vocational schools was obtained from various government agencies. In addition to this a list of boilers licensed by the Nova Scotia Department of Labour was obtained from the chief boiler inspector. Boilers must be licensed if the rated pressure is in excess of 100 kPa (15 psi) or in the case of hot water boilers if they are rated in excess of 120 kw (160 HP). The original terms of reference stated this study should focus on boilers in the 112 kw (150 HP) or 6.3 kg/sec (5,000 pph) range. Once this process was completed a total of 253 potential sites resulted. A detailed questionnaire was compiled and mailed to all the potential sites. Response to this questionnaire was approximately 20% with twenty-two respondents indicating an interest in pursuing the matter further. From this list the sites that had boilers nearest the size range being considered were selected, site visits and evaluations made in some cases and from this three sites were selected. The sites selected are:

1. Sunset Adult Residential Centre
2. ABCO Plastics Division
3. Britex Limited

The woodlot co-operatives and any interested contractors will have to become familiar with all the financial implications prior to entering into any supply contracts. As well, the owners must become aware of the expected magnitude of funds they may have to issue to install new equipment. As an aid to the owner, financial analysis have been performed on the Abco Plastics site and the Sunset Adult Residential Centre and are included under Appendix 5. Using Case 1.1 as an indicator, it shows that for a 7062 MJ unit (200 HP)

that only $200,000 can be spent with a funding level of $100,000 if an IRR of 20% is to be obtained. As well, it shows that maximum fuel price required to meet this objective must be $55.40/ODT, a figure that is close to that used in the financial models of the wood chip business.

In the case of the Sunset Adult Residential Centre a new plant cannot be afforded on the basis of IRR at 0.20. Case 2.1 shows that at a plant cost of $140,000 and a funding level of $100,000 with an IRR of 0.15, that maximum fuel prices cannot exceed $56.27/ODT. These figures are felt to be representative of a typical financial assessment and have been computed to give some idea of what maximum prices wood chip fuel should be.

Abco Plastics was chosen because its boiler plant capacity closely matched that stated in the terms of reference. As well, Dale Forestry Products has expressed a keen interest in supplying forest residue in the form of chips to Abco Plastics and generates sufficient residue to match demand. It was also indicated that a five year return on investment might be looked on favourably.

The Sunset Adult Residential Centre was chosen because it's boiler plant is fast approaching replacement and because it has a year round process load for the laundry and kitchen. They have also had discussions with the North Nova Forest Owners who have expressed some interest in supplying chips to this facility.

Britex Limited was the third choice and was chosen because of a year round process load and the fact that they have already submitted bids on two wood fired boilers. They have a long term interest in reducing energy costs and indicated a five year return on investment would be acceptable.

5.2 Government Grants and Subsidies

Presently, both the Federal and Provincial Governments have several programs in place that are designed to reduce energy consumption and alternate energy sources. The program that can be applied to the three demonstration projects is the "Pilot Projects Program". The objective of this program is "To encourage the use of energy conservation and renewable energy technologies that are not currently in widespread use but that are beyond the research and development stage."

All sectors of the economy are elegible for assistance, and financial support can vary from 10% to 100%. Funding source is 80% from the Federal government and 20% from the Province of Nova Scotia. This program has funded in excess of 50 major demonstration projects and is now slated to expire March 31, 1984.

For the purposes of site financial analysis a maximum funding level of $100,000.00 per site has been assumed. As levels of funding became clearer a re-iteration of the analysis' will be required to determine final IRR's.

6.0 FINANCIAL ANALYSIS

6.1 Introduction

A financial analysis involving various business models has been prepared in conjunction with a five year pro forma profit plan. Income statements for each model were prepared based on estimated sales volumes, sales prices, capital, operating and overhead costs. The results of each model have been included under Appendix 3.

6.2 Assumptions

The principal assumptions used in the financial model analysis are as follows:

(a) All costs and revenues are in 1983 dollars. Sales prices and volumes are each escalated at 7% per year and costs are escalated at 5% per year.

(b) Certain operations are performed on a contract basis but are assumed to be part of a parent organization. These include harvesting costs for machinery, labour and overheads associated with such an operation.

(c) Subsidies that could apply to silviculture treatments have been included. It is assumed 50% of the residue harvest will qualify for some form of subsidy. The subsidy used equals $14.00 per bone dry tonne which is very close to current maximum subsidies under the FRDA program.

(d) Wage rates for operating personnel have been set at $8.25 per hour plus 17% for statutory payroll costs and fringe benefits.

(e) Depreciation is calculated on a double declining balance basis. An average asset life of ten years has been assumed for equipment.

(f) Interim storage for chips has been costed on a rental basis.

(g) Interest charges of 13.5% per year are applied to bank loans for capital borrowing and inventory costs.

(h) Equity invested in the business is 25% of the total assets.

(i) Cash flow at year end is used to reduce bank loans in the year following.

(j) Tax rates of 24% on the first $250,000 of taxable income and 50.9% on the balance are used.

6.3 Financial Viability

Four financial models of a wood chip business have been assembled primarily to demonstrate the effect of sales volumes on cash flow.

(a) Model 1 assumes a pessimistic stance. The assumptions are that only one customer will be obtained and that of the harvested land, 50% will qualify for some form of subsidy. Cash flow results for this model show substantial outlays for all five years and would not be considered a success. The sales price used generates a zero % return on investment. This price must be raised to $68.00/ODT if a 20% return on investment is to be obtained

(b) Model 1.1 takes the same pessimistic stance but assumes all harvested land will qualify for maximum subsidy. Cash flow for this model yields positive results in the first year but only yields a five year DCFROI of 2.5%.

(c) Model 1.2 uses the price per tonne required to yield a 20% DCFROI. This equals $68/ODT and shows the net results on profit and cash flow.

(d) Model 2 takes a stance based on a probable series of events. The key assumptions are that one new customer will be added in year three and year five. As well, it is assumed 50% of the harvested

land will qualify for maximum site preparation assistance. Positive cash flow for this analysis does not occur until a price per tonne yielding a 20% DCFROI is used. This equals $60.00/ODT for this model.

(e) Model 3 is an optimistic projection of events and assumes aggressive marketing techniques have been applied to yield one new customer per year with an average consumption of 2,000 green tonnes each. Again it is assumed 50% of the harvest has qualified for maximum subsidy which has been distributed over the entire production volume. Results of this model do not show a positive cash flow being obtained until the second year and uses a price of $56.00/ODT to yield a 20% DCFROI.

(f) Model 4 was prepared to show the minimum volume required to obtain a positive cash flow during the first year. Again it is assumed 50% of the harvest has qualified for assistance. Results show 9500 tonnes would be required to show a small positive cash flow.

6.4 Financial Sensitivity and Summary

From the four models prepared it is evident that many factors end up contributing significantly to the financial success of a wood chip fuel industry.

The following are seen to have major impacts on costs of the finished wood chip product.

(a) the method of harvest.

(b) the amount of residue available on each site

(c) the delivery distance

(d) the choice of production equipment and relevant financing

(e) the cost of interim storage

(f) the cost of delivery to the consumer

(g) sales price

(h) sales volumes

(i) the effect of FRDA silviculture subsidies

(j) the effects of the world oil price.

Any upset in any of these listed factors can affect the end cost of the product drastically. A drop in the world oil price could place downward pressure on the delivered price of chips and could affect the acquisition of new customers if their present oil burning facilities are very efficient.

A rise in production volumes on the other hand, could help increase the efficiency of the operation and allow the supplier to maintain price levels for a longer period of time, thus enhancing the chances of increasing his future markets. Storage, delivery and finance charges have to be considered as well. At low production volumes storage time increases whereas at high production volumes storage may not even be required. The same is true of financing charges on the chipper and other equipment.

A high production volume in year one would enable the chipper to be paid off within that year whereas low production volumes would in all probability dictate a five year financing period. Delivery distances, too, have major effects. The rise in price is directly proportional to distance. If, for instance, interim storage can be avoided and deliveries made straight from the landing to the customer, the interim storage and handling charges are avoided. Depending on volumes produced, and whether or not a fixed price contract is in place this can benefit either the producer or the customer. In the long run, any savings would serve to stabilize wood chip pricing and increase the chances of a growing and self-sustaining market.

Summary

Certainly a skilled individual will be required if new customers are to be created and a wood chip fuel industry is to grow. Access to lands yielding high residue volumes and qualifying for subsidies should clearly be the main targets for the production end of the business. Subsidies help increase cash flow and can allow more flexibility in any marketing approach.

To increase the number of customers, tight control of costs and very skilled marketing knowledge must be applied. This could eventually involve financing part of the installation costs or becoming involved as an agent for certain lines of wood chip burning equipment. Given the fact that 9,500 green tonnes of chips is the minimum volume required to turn a positive cash flow in year one, the producer, once established, must strive to increase his market right from the outset if the business is to prosper and survive. Only a well integrated operation encompassing all phases from production to consumption will be guaranteed any success and certainly direction and support of this industry will be required from government levels in the initial stages of growth and development.

7.0 BUSINESS SKILLS, TYPE AND LOCATION

This section reviews the type and source of business and labour skills required for the industry.

7.1 Business and Labour Skills

(a) Harvesting

Harvesting and processing of forest products is a well established major industry in Nova Scotia. Skills for equipment operation are largely in place and training for new operators can be accomplished quickly. Where harvest of residue on the forest floor is involved detailed instruction will be involved if economic production rates are to be realized. Initially, production yields and rates should be tabulated so the operators and owners of the business realize the effects their efforts have on delivered price. Semi-skilled labour is presently available for the harvest equipment operation and no difficulties can be foreseen in this regard.

(b) Transportation and Delivery

This section of the industry is also well established in Nova Scotia and with a large labour pool currently available no difficulty is foreseen in staffing this phase of the operation.

(c) Processing

Initially during the first few weeks of any chipping operation, skills associated with chipper maintenance will have to be learned. Presently the best means of accomplishing this would be to train personnel in the manufacturers plant so the individual can come to appreciate all phases of chipper operation and maintenance. Once learned, the necessary skills can be passed on by trained operators to other individuals.

The same would apply to any chip screening operations. Depending on volumes, this may not be required but as the operation grows screening will become more important. If a customer has a large enough demand he may wish to install his own screen but assuming either producer or supplier install such a device knowledge of operation and maintenance will be required. These skills can be acquired through short courses in the manufacturers plant and are easily passed along.

(d) Services to Users

Unless the wood chip industry begins to make inroads into the residential market it is expected few user services will be required. Most institutional and commercial facilities have trained personnel on hand capable of meeting most routine maintenance and operation needs. Some refresher training will be required for operating personnel but will be of a minor nature. Familiarity will be required with wood chip handling equipment but can normally be acquired during the start-up phases with manufacturers representatives in attendance.

(e) Business Management

The business skills required to operate a wood chip fuel industry are largely in place. Where the emphasis must be placed is on the marketing aspects. This industry will not grow without support from government or intensive sales efforts by equipment and chip producer representatives. Most contractors as they exist do not have the skills or the means to launch an effective marketing campaign and to sustain it for long periods of time. This will be required and in the past has come from the manufacturing sector and has

been limited by funds available. With the case of the industrial commercial user the wood chip supplier will face an uncertain future without a door to door sales campaign that has been well prepared and is well delivered. Working in concert with one or more manufacturing agents will help the chip producer to look forward with some degree of confidence and allow him to adjust his business projections accordingly.

7.2 Type of Business Operation

The wood chip fuel industry can be established either as a separate entity or as part of an existing pulpwood, sawlog, silviculture contracting operation. If established separately, chipping and delivery of the product would form the main components of the business and harvesting would be done under sub-contracts. This would require the co-operation of two individuals and a sharing of subsidies that might apply to the harvest operation.

The other approach is to expand an established pulpwood business by purchasing a chipper and small delivery van. This approach would probably have the most tax advantages and not require expansion of the harvesting equipment as most contractors are currently working below capacity due to imposed quota limits. As well, this could assure a more reliable supply of raw materials and guarantee more consistent delivery patterns.

However, no matter what method is chosen, provided a minimum economic tonnage can be obtained the business can survive and prosper. Skilled and intelligent field operations in concert with knowledgeable marketing will be required to pave the way for an expanding enterprise.

7.3 Business Location

Business location will initially be controlled by the customer. Delivery costs are the easiest to control if the raw material and the storage site are close to the consumer. Certainly operations will end up being concentrated within an 80 km radius as transportation costs contribute significantly to finished product costs at this distance range.

8.0 BENEFITS OF A RESIDUE WOOD CHIP INDUSTRY

8.1 Immediate Benefits

By establishing demonstration sites some immediate benefits result.

(a) The immediate objective of demonstrating harvesting techniques, and the equipment required to process the chips and the equipment required to consume the chips is accomplished and allows other interested parties to view the operation.

(b) An installation capable of reducing energy costs and displacing significant quantities of oil is created.

(c) A reduction in the foreign import oil subsidy is accomplished.

(d) and additional jobs in the forest industry are created.

8.2 Long Term Benefits - Forest Management

In addition to the immediate benefits other longer lasting forces come into play. The need for an intensive forest management program to maintain and increase the productivity, quality and diversity of the Nova Scotia forest resource is well recognized by all members of the forest industry. Without any silvicultural investment the province's annual allowable cut would decrease significantly and result in the loss of thousands of jobs.

If present levels of silvicultural investment are continued, then the present level of harvest can be maintained. Any increase in silviculture activity would result in a corresponding increase in the A.A.C., resulting in very significant economic benefits to the province.

The establishment of a wood chip fuel industry in Nova Scotia, with forest residue as the main supply of chips, would benefit management of the forest resource.

The collection of logging residue and residual trees from commercially harvested stands will reduce site preparation costs, and may also reduce the chances of forest fire on any given site. Chipping such material and selling it as fuel allows the owner or contractor to earn income while reducing reforestation costs. In some instances where the cost of producing chips from site preparation exceeded revenue for the product, silviculture assistance could be available.

As well, having a market (in the form of chips) for poor quality and unutilized hardwood species, makes the release of natural softwood regeneration under conventionally non-marketable hardwood inventories more feasible. Once the hardwood has been removed, the forest regeneration can then begin.

Perhaps the greatest benefit to forest management lies in the harvesting of non-commercial and budworm-killed stands.

As stated earlier, at least 10% of the province's forest resource consists of older, understocked stands, lacking in vigour and genetically low graded, growing wood at a rate which does not keep pace with natural losses. If these stands can be harvested economically producing chips for energy, the sites can be restored to full productivity by reforestation and subsequent silvicultural treatments. Again, if the salvage of these stands and chip production are combined, both operations become more cost-effective.

With any forest disaster, such as the present spruce budworm infestation, which results in large volumes of dead wood, some salvage is possible, but very large volumes are wasted due to quality restrictions and market constraints or conventional products. Chipping of this dead wood provides a very sensible use for this otherwise wasted resource. As well, it

clears the way for follow-up silviculture treatments (reforestation, clearing, etc.).

In summary, it is clear that establishing a wood chip fuel industry would have significant beneficial effects on forest management in Nova Scotia. The costs of some silvicultural treatments could be reduced, while some treatments which cannot be undertaken under present market conditions could be done utilizing the wood waste as chips.

9.0 CONCLUSION AND RECOMMENDATION

From preceding discussions the potential that exists for manufacturing wood chip fuel from forest residues is large. Establishment of a chip supplier should be an easy task given the interest expressed by established woodlot group ventures and contractors. Beyond that, interest by consumers is reasonably high and will guarantee one source of income to each supplier for at least three to five years. To sustain growth, however, will require the applications of many and varied skills. These skills are available but must be co-ordinated in concert with the remaining components of the industry. This study has demonstrated that production of wood chips from residue is economically possible and that prospects of demand are present to support this business.

Conclusions

The following represents the findings and conclusions of this study.

(a) Forest residue in its various forms is readily available in all areas of the province. Presently in excess of 1,000 kilo-tonnes of residue are produced each year from harvest and silviculture operations and over 17,000 kilo-tonnes are available from non commercial stands, past logging activities, budworm damage, and unutilized species.

(b) Supply of residues for wood chips from woodlot group ventures could exceed 25,000 tonnes and could support several consumers.

(c) The woodlot cooperatives could eventually support up to four customers consuming approximately 2,000 green tonnes each per year.

(d) That the selection of harvest equipment greatly influences productivity. The most efficient machinery is the skidder mounted slash rake with production rates of approximately 3.15 oven dry tonnes per hour when harvesting residue. In low grade stands the feller forwarder is the most efficient generating 4.34 oven dry tonnes per hour.

(e) Roadside costs of chips per green tonne will vary but will average $26.00.

(f) Delivery costs of chips per green tonne will be approximately $.08 per tonne kilometre and cost $6.50 per green tonne at a range of 80 km.

(g) Costs to the consumer on a contract basis will vary from $30.00 to $35.00 per green tonne at 44% moisture content and contain an escalation clause amounting to 7% per year.

(h) Government Subsidies will be required to encourage the establishment of a wood chip business based on residue harvests. With one guaranteed customer and subsidies on harvested land in place suppliers can be found to produce chips from residue on a continuing basis.

(i) Without subsidies in place, pressure will placed on high yield stands and, therefore, conflict with the normal forest industry supply source, could result.

(j) A minimum production of 2,000 green tonnes per year at a sales price of $68.00 will be required to generate a positive cash flow and a 20% DCFROI.

(k) A minimum production of 9500 green tonnes will be required to generate a break-even cost operation in the first year at a sales price of $50 per green tonne.

(l) That to make it attractive for the consumer, wood chip fuel prices must be controlled to the $50 to $55/ODT range if 15 to 20% DCFROI are to be possible for the demonstration site costs.

(m) Skilled individuals with marketing knowledge in conjunction with a positive government attitude will be required if the wood chip fuel markets are to grow.

(n) The benefits to forestry will have significant effects. Preparation of harvested tracts for planting eases the burden on the current resource. As markets grow and site preparation and planting continues a guaranteed source of future biomass becomes more realizable.

Recommendations

From attitudes and responses of those surveyed during this study and the findings contained herein the following are seen as recommendations.

(a) Awareness of the benefits of burning biomass at the institutional commercial level must be improved. This could be accomplished through seminars, media campaigns and contact on a personal level through manufacturing and government representatives. As well, all existing funding and grant programs should be continued.

(b) Subsidies for site clearing and preparation for planting should remain in place for participating chip producers.

(c) Subsidies to producers should be given to maintain a break-even operation.

(d) Partial funding or grants for marketing should be made available to contractors producing wood chips from residue.

(e) That the provincial government in lieu of the above adopt an effective high profile marketing campaign to raise public awareness of the success recent demonstration projects have attained. This marketing effort could focus attention on all forms of biomass residue as a source for wood chips and the resulting cost benefits that can be obtained.

(f) Monitor all phases of production initially. This would involve production studies and time trials at the harvest site with a view to increasing the producers cost effectiveness and awareness level.

(g) Control the source of supply where possible to reduce pressure that might be applied to a high yield commercial stand. This could be accomplished by a special subsidy available to chip producers who harvested in stands designated by Nova Scotia Lands and Forests. This, however, would be applied to interest charges on production machinery and be phased out once production levels rise to a self-supporting level. This would still require the site preparation subsidy to remain in place.

(h) In conjunction with a marketing campaign seek out new markets.

(i) Extend the life of existing programs that subsidize the costs of converting boilers to biomass fuel.

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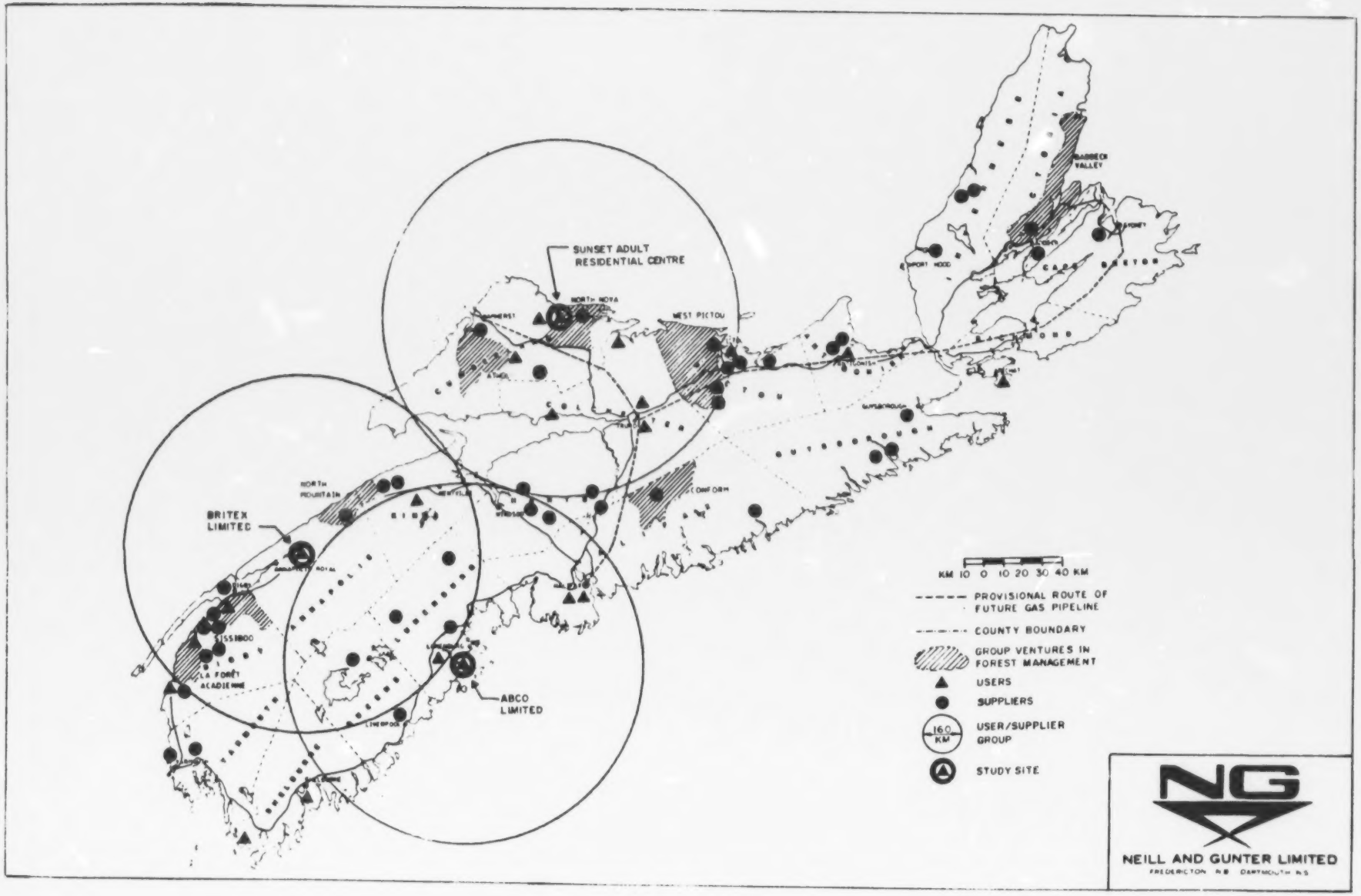
APPENDIX 1
MAP OF USER SUPPLIER GROUPS


SUNSET ADULT RESIDENTIAL CENTRE
BRITEX LIMITED
ABCO LIMITED
KM 10 0 10 20 30 40 KM
PROVISIONAL ROUTE OF FUTURE GAS PIPELINE
COUNTY BOUNDARY
GROUP VENTURES IN FOREST MANAGEMENT
USERS
SUPPLIERS
160 KM
USER/SUPPLIER GROUP
STUDY SITE
NEILL AND GUNTER LIMITED
FREDERICTON N.B. DARTMOUTH N.S.

1.1 LIST OF COMPANIES AND INSTITUTIONS INTERESTED IN BURNING WOOD CHIPS

1. Richmond Fisheries
2. Sunset Adult Residential Centre - Pugwash
3. Universite Sainte Anne - Church Point
4. ABCO Limited - Lunenburg
5. Baddeck Elementary School - Baddeck
6. Saint Francis Xavier University - Antigonish
7. Scotia Marine Products - Lower Woods Harbour, Shelburne Co.
8. Municipality of Shelburne
9. Gordon's Greenhouses - Oxford
10. Avon Valley Greenhouses Limited - Falmouth
11. All Saints Springhill Hospital - Springhill
12. North Colchester Forest Co-operative Ltd. - Truro
13. Hawker Siddeley Canada Inc. Trenton Works Division - Trenton
14. Scotia Greenhouses Limited - Woodville,King's Co.
15. Dominion Chair Co. Ltd. - Bass River
16. National Sea Products Ltd. - Halifax
17. Camp Hill Hospital - Halifax
18. Dawson Memorial Hospital - Bridgewater
19. E.M. Comeau & Sons (1977) Ltd. - Meteghan
20. Crossley Karastan Carpet Mills Ltd. - Truro
21. Village of Weymouth, N.S.
22. Village of Tatamagouche

1.2 LIST OF GROUP VENTURES AND LAND HOLDERS INTERESTED IN SUPPLYING WOOD CHIPS

1. La Foret Acadienne (?)
2. Sissiboo - Digby
3. North Mountain Woodlands Limited - Middleton
4. Conform Limited - Middle Musquodoboit
5. Baddeck Valley Wood Producers - Baddeck
6. West Pictou Forest Owners Limited - Pictou
7. Athol Cooperative Limited - Nappan
8. North Nova Forest Owners - Pugwash
9. Dale Forestry Ltd. - Lunenburg
10. Lewis Lumber Co. Ltd. - Weymouth
11. Scott Maritimes Limited - New Glasgow
12. Bowater Mersey Paper Company Limited - Liverpool
13. Bragg Lumber Co. Limited - Collingwood, Cumberland Co.
* 14. North Colchester Forest Co-operative Limited
15. Greif Containers Inc.

***NOTE:** North Colchester Forest Co-operative Limited is currently applying for Group Venture status.

1.3 LIST OF CONTRACTORS

INTERESTED IN SUPPLYING WOOD CHIPS

1. Millstream Forest Products - Eureka, N.S.
2. Marshall Smith Cont. - New Glasgow
3. Atlantic Forestry Consultants - Antigonish
4. John W. McCarron Ltd. - Antigonish
5. Hants Co. Woodlot Services - Woodville, Hants Co.
6. Joseph A. LeBlanc Woods Contractor Ltd. - Margaree, Inverness Co.
7. George Ferguson MacPail - Elmsdale
8. Highland Pulp Ltd. - Margaree, Inverness Co.
9. Ronald Russell - Blockhouse, Lunenburg Co.
10. C.F. Dickson Forest Products Ltd. - Stellarton
11. Carl Manthorne Pulp Contracting Ltd. - Country Harbour, Guysboro Co.
12. Hayne Bros. Cont. Ltd. - Country Harbour, Guysboro Co.
13. Northumberland Logging - Merigomish, Pictou Co.
14. Pugwash Pulp Ltd. - Pugwash
15. Moser Pulpwood Ltd. - Moser River, Halifax Co.
16. Eric Hurlburt - South Ohio, Yarmouth Co.
17. Foresite Ltd. - Yarmouth, N. S.
18. Aaron L. Phillips - Baddeck
19. Marshall Forestry - Weymouth
20. E.E. Tanner Lumbering Ltd. - Milford Station, Hants Co.
21. Lewis Lumber Co. Ltd. - Weymouth
22. H.M. Colwell & Sons Ltd. - Weymouth
23. Clarence Patrick Larder Jr. - New Ross, Lunenburg Co.
24. Harry Morse - Berwick

25. Vernard R. Lynch - East Uniacke, Hants Co.

26. Saulnierville Lumber Ltd. - Corberrie, Digby Co.

27. A.C. Campbell Contractors Ltd. - Mabou, N.S.

28. English Resources Limited - Aylesford

29. Roger Weare, Caledonia, Queens Co.

30. John R. Kowalczyk, Sydney Forks

31. James Bremner, Falmouth, Hants Co.

32. C. Ainley Clkye, Guysborough

APPENDIX 2
SOURCE OF RESIDUE AND ASSUMPTIONS

APPENDIX 2

Residue Source	Assumptions
1. Logging residue and residuals from Commercial harvests	1. Avg. 5 yr harvest (1977-1981) equals 3,900,000 m^3 2. 40% of original above ground biomass left on site after conventional logging. 3. 8% of residue merchantable table for conventional roundwood products.
2. Residue from Silvicultural Operations	1. Average yield from cleaning = 5.6 m^3/ha 2. Average yield from thinning and salvage = 39 m^3/ha.
3. Non-commercial Stands	1. 400,000 ha classified as non-commercial 2. Avg. vol. = 39 m^3/ha
4. Residue from Past Logging	1. 1042 oven dry kilotonnes produced annually over past 3 years. 2. 40% of previously logged areas regenerated (natural or artificial) and, therefore, residue not available.
5. Dead trees (budworm)	1. 24,000,000 m^3 dead. 2. 30% too rotten or already salvaged. 3. 10% already accounted for in non-commercial stands.
6. Unutilized Species	1. 10% of hardwood resource comprised of unutilized species. 2. 10% of unutilized species already accounted for in non-commercial stands. 3. Total hardwood resource is 87,000,000 m^3.

APPENDIX 3
FIVE YEAR PRO FORMA PROFIT PLAN

APPENDIX 3

Wood Chip Supply Business
Summary of Capital Costs and Labour Requirements

Capital Costs

Buildings		
- Office (Rent)		
- Plant (Equipment and Product Storage)		
Mobile Equipment		
- Chip Delivery Truck (Need)		12,000
- Loader (Rent)		
Harvest Equipment (User Pay Sharing)		
- (1) Chipper		70,000
- (2) Skidders or Porters		
Process Equipment		
Truck Scales (Rent or Used)		
Screen System		0
Drying System		0
Working Capital	20,000	
Total	102,000	

Labour
Manager - 1
Operator - 1 (Part Time)

NOTES:
1. This business is assumed to be integrated with an established pulp or log harvesting enterprise.
2. Capital for harvesting equipment excepting the chipper is borne by the established company.

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 1: WOOD CHIP SUPPLY BUSINESS

OUTLOOK: PESSIMISTIC ONE CUSTOMER ONLY
SUBSIDY ASSUMED FOR 50% OF HARVEST

YEAR		1	2	3	4	5
SALES VOLUME BDt/Y		2000	2000	2000	2000	2000
SALES PRICE $/BDt		50.00	53.50	57.25	61.25	65.54
TOTAL SALES	$	100000	107000	114490	122504	131080
PROD. COST $/BDt		36.00	37.80	39.69	41.67	43.76
TOTAL CHIP COST		72000	75600	79380	83349	87516
CHIP TRANPORT		13000	16170	16979	17827	18719
LOADER OP COST	$	3000	3371	3787	4254	4780
TOTAL VAR COST	$	88000	95141	100145	105431	111015
INSURANCE	$	200	210	221	232	243
POWER	$	1200	1272	1348	1429	1515
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	5000	5250	5513	5788	6078
STORAGE RENTAL		6000	6300	6615	6946	7293
MAINTENANCE + LAB		8410	8831	9272	9736	10222
TOTAL FIX COST	$	21210	22287	23418	24607	25856
INTEREST	$	11847.5	13227	16065	19082	22276
INCOME	$	-21058	-23654	-25138	-26615	-28067
DEPRECIATION	$	20400	16320	13056	10445	8356
TAXABLE INCOME	$	-41458	-39974	-38194	-37060	-36423
TAXES	$	0	0	0	0	0
NET PROFIT	$	-41458	-39974	-38194	-37060	-36423
CASH FLOW	$	-21058	-23654	-25138	-26615	-28067

FIVE YEAR PROFORMA PROFIT PLAN

MODEL1.1 WOOD CHIP SUPPLY BUSINESS

OUTLOOK: PESSIMISTIC ONE CUSTOMER ONLY
SUBSIDY ASSUMED FOR 100% OF HARVEST

YEAR		1	2	3	4	5
SALES VOLUME BDt/Y		2000	2000	2000	2000	2000
SALES PRICE $/BDt		50.00	53.50	57.25	61.25	65.54
TOTAL SALES	$	100000	107000	114490	122504	131080
PROD. COST $/BDt		25.00	26.25	27.56	28.94	30.39
TOTAL CHIP COST		50000	52500	55125	57881	60775
CHIP TRANPORT		13000	16170	16979	17827	18719
LOADER OP COST	$	3000	3371	3787	4254	4780
TOTAL VAR COST	$	66000	72041	75890	79963	84274
INSURANCE	$	200	210	221	232	243
POWER	$	1200	1272	1348	1429	1515
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	5000	5250	5513	5788	6078
STORAGE RENTAL		6000	6300	6615	6946	7293
MAINTENANCE + LAB		8410	8831	9272	9736	10222
TOTAL FIX COST	$	21210	22287	23418	24607	25856
INTEREST	$	11847.5	10587	10337	9755	8774
INCOME	$	943	2086	4845	8179	12176
DEPRECIATION	$	20400	16320	13056	10445	8356
TAXABLE INCOME	$	-19458	-14234	-8211	-2265	3820
TAXES	$	0	0	0	0	917
NET PROFIT	$	-19458	-14234	-8211	-2265	2903
CASH FLOW	$	943	2086	4845	8179	11259

FIVE YEAR PROFORMA PROFIT PLAN

MODEL1.2 WOOD CHIP SUPPLY BUSINESS

OUTLOOK: PESSIMISTIC ONE CUSTOMER ONLY
SUBSIDY ASSUMED FOR 50% OF HARVEST

YEAR		1	2	3	4	5
SALES VOLUME BDt/Y		2000	2000	2000	2000	2000
SALES PRICE $/BDt		68.00	72.76	77.85	83.30	89.13
TOTAL SALES	$	136000	145520	155706	166606	178268
PROD. COST $/BDt		36.00	37.80	39.69	41.67	43.76
TOTAL CHIP COST		72000	75600	79380	83349	87516
CHIP TRANPORT		13000	16170	16979	17827	18719
LOADER OP COST	$	3000	3371	3787	4254	4780
TOTAL VAR COST	$	88000	95141	100145	105431	111015
INSURANCE	$	200	210	221	232	243
POWER	$	1200	1272	1348	1429	1515
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	5000	5250	5513	5788	6078
STORAGE RENTAL		6000	6300	6615	6946	7293
MAINTENANCE + LAB		8410	8831	9272	9736	10222
TOTAL FIX COST	$	21210	22287	23418	24607	25856
INTEREST	$	11847.5	8907	6687	3989	1520
INCOME	$	14943	19186	25456	32579	39877
DEPRECIATION	$	20400	16320	13056	10445	8356
TAXABLE INCOME	$	-5458	2866	12400	22134	31521
TAXES	$	0	688	2976	5312	7565
NET PROFIT	$	-5458	2178	9424	16822	23956
CASH FLOW	$	14943	18498	22480	27267	32312

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 2 WOOD CHIP SUPPLY BUSINESS

OUTLOOK: PROBABLE ADD ONE CUSTOMER EVERY 2ND YEAR SUBSIDY ASSUMED FOR 50% OF HARVEST

YEAR		1	2	3	4	5
SALES VOLUME BDt/Y		2000	2000	4000	4000	6000
SALES PRICE $/BDt		50.00	53.50	57.25	61.25	65.54
TOTAL SALES	$	100000	107000	228980	245009	393239
PROD. COST $/BDt		36.00	37.80	39.69	41.67	43.76
TOTAL CHIP COST		72000	75600	158760	166698	262549
CHIP TRANPORT		13000	16170	33957	35655	56156
LOADER OP COST	$	3000	3371	3787	4254	4780
TOTAL VAR COST	$	88000	95141	196504	206607	323486
INSURANCE	$	200	210	221	232	243
POWER	$	1200	1272	1348	1429	1515
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	5000	5250	11025	11576	12155
STORAGE RENTAL		6000	6300	6615	6946	7293
MAINTENANCE + LAB		8410	8831	18544	19471	30667
TOTAL FIX COST	$	21210	22287	38202	40130	52378
INTEREST	$	11847.5	13227	17585	20383	24556
INCOME	$	-21058	-23654	-23311	-22112	-7181
DEPRECIATION	$	20400	16320	13056	10445	8356
TAXABLE INCOME	$	-41458	-39974	-36367	-32557	-15537
TAXES	$	0	0	0	0	0
NET PROFIT	$	-41458	-39974	-36367	-32557	-15537
CASH FLOW	$	-21058	-23654	-23311	-22112	-7181

FIVE YEAR PROFORMA PROFIT PLAN

MODEL2.1 WOOD CHIP SUPPLY BUSINESS

OUTLOOK: PROBABLE ADD ONE CUSTOMER EVERY 2ND YEAR SUBSIDY ASSUMED FOR 50% OF HARVEST

YEAR		1	2	3	4	5
SALES VOLUME BDt/Y		2000	2000	4000	4000	6000
SALES PRICE $/BDt		60.00	64.20	68.69	73.50	78.65
TOTAL SALES	$	120000	128400	274776	294010	471887
PROD. COST $/BDt		36.00	37.80	39.69	41.67	43.76
TOTAL CHIP COST		72000	75600	158760	166698	262549
CHIP TRANPORT		13000	16170	33957	35655	56156
LOADER OP COST	$	3000	3371	3787	4254	4780
TOTAL VAR COST	$	88000	95141	196504	206607	323486
INSURANCE	$	200	210	221	232	243
POWER	$	1200	1272	1348	1429	1515
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	5000	5250	11025	11576	12155
STORAGE RENTAL		6000	6300	6615	6946	7293
MAINTENANCE + LAB		8410	8831	18544	19471	30667
TOTAL FIX COST	$	21210	22287	38202	40130	52378
INTEREST	$	11847.5	10827	12329	9423	7191
INCOME	$	-1058	146	27741	37849	88832
DEPRECIATION	$	20400	16320	13056	10445	8356
TAXABLE INCOME	$	-21458	-16174	14685	27404	80476
TAXES	$	0	0	3524	6577	19314
NET PROFIT	$	-21458	-16174	11160	20827	61162
CASH FLOW	$	-1058	146	24216	31272	69518

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 3 WOOD CHIP SUPPLY BUSINESS

OUTLOOK: OPTIMISTIC AD ONE CUSTOMER EVERY YEAR SUBSIDY ASSUMED FOR 50% OF HARVEST

YEAR		1	2	3	4	5
SALES VOLUME BDt/Y		2000	4000	6000	8000	10000
SALES PRICE $/BDt		50.00	53.50	57.25	61.25	65.54
TOTAL SALES	$	100000	214000	343470	490017	655398
PROD. COST $/BDt		36.00	37.80	39.69	41.67	43.76
TOTAL CHIP COST		72000	151200	238140	333396	437582
CHIP TRANPORT		13000	27300	42998	60197	79008
LOADER OP COST	$	3000	6300	9923	13892	18233
TOTAL VAR COST	$	88000	184800	291060	407484	534823
INSURANCE	$	200	210	221	232	243
POWER	$	1200	1272	1348	1429	1515
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	5000	10500	16538	23153	30388
STORAGE RENTAL		6000	6300	6615	6946	7293
MAINTENANCE + LAB		8410	17661	27816	38943	51112
TOTAL FIX COST	$	21210	36367	52987	71178	91056
INTEREST	$	11847.5	14747	18897	22753	25641
INCOME	$	-21058	-21914	-19473	-11398	3878
DEPRECIATION	$	20400	16320	13056	10445	8356
TAXABLE INCOME	$	-41458	-38234	-32529	-21843	-4478
TAXES	$	0	0	0	0	0
NET PROFIT	$	-41458	-38234	-32529	-21843	-4478
CASH FLOW	$	-21058	-21914	-19473	-11398	3878

FIVE YEAR PROFORMA PROFIT PLAN

MODEL3.1 WOOD CHIP SUPPLY BUSINESS

OUTLOOK: OPTIMISTIC ADD ONE CUSTOMER EVERY YEAR SUBSIDY ASSUMED FOR 50% OF HARVEST

YEAR		1	2	3	4	5
SALES VOLUME BDt/Y		2000	4000	6000	8000	10000
SALES PRICE $/BDt		56.00	59.92	64.11	68.60	73.40
TOTAL SALES	$	112000	239680	384686	548819	734046
PROD. COST $/BDt		36.00	37.80	39.69	41.67	43.76
TOTAL CHIP COST		72000	151200	238140	333396	437582
CHIP TRANPORT		13000	27300	42998	60197	79008
LOADER OP COST	$	3000	6300	9923	13892	18233
TOTAL VAR COST	$	88000	184800	291060	407484	534823
INSURANCE	$	200	210	221	232	243
POWER	$	1200	1272	1348	1429	1515
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	5000	10500	16538	23153	30388
STORAGE RENTAL		6000	6300	6615	6946	7293
MAINTENANCE + LAB		8410	17661	27816	38943	51112
TOTAL FIX COST	$	21210	36367	52987	71178	91056
INTEREST	$	11847.5	13307	14202	12935	8936
INCOME	$	-9058	5206	26437	57222	99232
DEPRECIATION	$	20400	16320	13056	10445	8356
TAXABLE INCOME	$	-29458	-11114	13381	46777	90876
TAXES	$	0	0	3212	11227	21810
NET PROFIT	$	-29458	-11114	10170	35551	69066
CASH FLOW	$	-9058	5206	23226	45996	77421

MODEL 4 14" CHIPPER C/W GRAPPLE
OUTLOOK: MIIMUM SALES TO GENERATE
+ CASH FLOW @ 50% SUBSIDY

SALES VOLUME	9500
SALES PRICE	50.00
TOTAL SALES	475000
CHIP PROD. COST	36.00
TOTAL CHIP COST	342000
CHIP TRANSPORT	66500
LOADER OP COST	3000
TOTAL VAR COST	411500
INSURANCE	300
POWER	1200
TELEPHONE	400
ADMINISTRATION	5000
STORAGE RENTAL	6000
MAINTENANCE + LAB	39948
TOTAL FIX COST	52848
INTEREST	10328
NET INCOME	325
DEPRECIATION	20400
TAXABLE INCOME	-20075
TAXES	0
NET PROFIT	-20075
CASH FLOW	325

CHIP1.S 12" CHIPPER C/W GRAPPLE
OUTLOOK: PESSIMISTIC ONE CUSTOMER ONLY

SALES VOLUME	600	600	600	600	600
SALES PRICE	52.00	55.64	59.53	63.70	68.16
TOTAL SALES	31200	33384	35721	38221	40897
CHIP PROD. COST	4.10	14.00	14.70	15.44	16.21
TOTAL CHIP COST	2460	8400	8820	9261	9724
CHIP TRANSPORT	7000	7350	7718	8103	8509
LOADER OP COST	2000	2100	2205	2315	2431
TOTAL VAR COST	11460	17850	18743	19680	20664
INSURANCE	200	210	221	232	243
POWER	0	0	0	0	0
TELEPHONE	0	0	0	0	0
ADMINISTRATION	0	0	0	0	0
STORAGE RENTAL	0	0	0	0	0
MAINTENANCE + LAB	0	0	0	0	0
TOTAL FIX COST	200	210	221	232	243
NON PRODUCTIVE LOAN PAYMENTS	7100	7100	7100	0	0
NET INCOME	12440	8224	9658	18310	19990
DEPRECIATION	7500	7500	0	0	0
TAXABLE INCOME	4940	724	9658	18310	19990
TAXES	2371	348	4636	8789	9595
NET PROFIT	4940	724	9658	18310	19990
CASH FLOW	10069	7876	5022	9521	10395

ASSUMPTIONS: PRODUCTION COSTS = $28./BDT

GRANT= $15000

METHOD= SLASH RAKE & SKIDDER OR WHOLE TREE
PROCESSING AT CENTRAL LANDING

OWNER ABSORBS SKIDDER COSTS=14.00/BDT

LABOUR COSTS ABSORBED BY BACK TO WORK GRANT IN THE FIRST YEAR

CAPITOL REQ'D AFTER GRANT= $15000

APPENDIX 4
LIST OF PARAMETERS FOR WOODCHIP PRODUCTION COSTS

APPENDIX 4

LIST OF PARAMETERS FOR WOOD CHIP

PRODUCTION COSTS

1. Production rates for harvesting residues and residuals come from references 4 and 12 and personal communications.

2. Pro-rated costs of logging operations are obtained from Reference 2.

3. Labour rates used equal $8.25 plus 17% for legislated benefits.

4. Consumer price index figures were obtained from Statistics Canada and the percent change calculated to pro-rate costs from Reference 2.

5. Financing charges were assumed to be 13.5%.

6. Chipper size was assumed to be 14 inch c/w grapple and blower, costing approximately $65,000.

APPENDIX 5
FINANCIAL ANALYSIS OF TYPICAL SITES

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

CASE 1 ABCO PLASTICS DIVISION

INPUT DATA & BASIC ASSUMPTIONS

1. Plant cost		9. DEMO GRANT			CASE 1a	CASE 1b	CASE 1c
1a	375000	1a	100000	17. % oil combus	.8	.8	.8
1b	375000	1b	100000				
1c	375000	1c	100000				
2. Plant size (MJ/hr)	7062	10. Net plant cost ($)		18. Heat content oil (j/l)	38700000	38700000	38700000
		1a	275000				
3. Existing oil use/year (l)	264000	1b	275000				
		1c	275000	19. % wood subs	.9	.9	.9
4. $/l oil	.314	11. Required IRR	.2				
		12. # yrs plant life (n)	20	20. Heat content wood (j/t)	20000000000	20000000000	20000000000
5. Current oil costs ($/yr)	82896						
		13. Plant salvage value @ n yrs,% & $	10	21. % wood combustion@% H2o	.6	.68	.73
6. Extra labour costs ($/yr)	0	1a	37500				
		1b	37500	22. %H20 in wood	.44	.3	.1
		1c	37500				
7. % Mtnc costs	5	14. PVIF(a)IRR n	4.869579734				
7.1 Extra maintenance costs ($/yr)		15. NPV,yr n,IRR	.0260840533	23. Wood fuel required (bdt/yr)	613.01	540.89	503.84
1a	18750						
1b	18750						
1c	18750	16. Tax rate	.5				
8. % oil use	10		.5				
8.1 Future oil use ($/yr)	8289.6						

Calculate maximum cost of wood fuel ; given above criteria

	CASE 1a WOOD @ 44%MC		CASE 1b WOOD @30%MC		CASE 1c WOOD @ 10%MC	
	Debit	Credit	Debit	Credit	Debit	Credit
1.Plant cost	275000.00		275000.00		275000.00	
2.Fuel saving		181650.91		181650.91		181650.91
3.P.V. maintenance	45652.31		45652.31		45652.31	
4.P.V. CCA		68750.00		68750.00		68750.00
5.P.V. salvage		978.15		978.15		978.15
6.P.V. loss on salvage CCA	244.54		244.54		244.54	
7.P.V. extra labour	0		0		0	
	320896.85	251379.06	320896.85	251379.06	320896.85	251379.06
Maximum price / bdt of wood fuel delivered =		-46.58		-52.79		-56.67

SITE2

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

CASE 2 SUNSET HOME NEW PLANT

INPUT DATA & BASIC ASSUMPTIONS

1. Plant cost		9. DEMO GRANT			CASE 1a	CASE 1b	CASE 1c
1a	375000	1a	100000	17. % oil combus	.75	.75	.75
1b	375000	1b	100000				
1c	375000	1c	100000				
2. Plant size (MJ/hr)	3531	10. Net plant cost ($)		18. Heat content oil (j/l)	38700000	38700000	38700000
		1a	275000				
		1b	275000				
3. Existing oil use/year (l)	212000	1c	275000	19. % wood subs	.9	.9	.9
		11. Required IRR	.2	20. Heat content wood (j/t)	20000000000	20000000000	20000000000
4. $/l oil	.293	12. # yrs plant life (n)	20				
5. Current oil costs ($/yr)	62116	13. Plant salvage value @ n yrs,% & $	10	21. % wood combustion@% H2o	.6	.68	.73
6. Extra labour costs ($/yr)	0	1a	37500	22. %H2O in wood	.44	.3	.1
		1b	37500				
		1c	37500				
7. % Mtnc costs	15	14. PVIF(a)IRR n	4.869579734	23. Wood fuel required (bdt/yr)	461.50	407.20	379.31
7.1 Extra maintenance costs ($/yr)		15. NPV,yr n,IRR	.0260840533				
1a	56250						
1b	56250						
1c	56250	16. Tax rate	.5				
8. % oil use	10		.5				
8.1 Future oil use ($/yr)	6211.6						

Calculate maximum cost of wood fuel ; given above criteria

	CASE 1a WOOD @ 44%MC		CASE 1b WOOD @ 30%MC		CASE 1c WOOD @ 10%MC	
	Debit	Credit	Debit	Credit	Debit	Credit
1.Plant cost	275000.00		275000.00		275000.00	
2.Fuel saving		136115.47		136115.47		136115.47
3.P.V. maintenance	136956.93		136956.93		136956.93	
4.P.V. CCA		68750.00		68750.00		68750.00
5.P.V. salvage		978.15		978.15		978.15
6.P.V. loss on salvage CCA	244.54		244.54		244.54	
7.P.V. extra labour	0		0		0	
	412201.47	205843.62	412201.47	205843.62	412201.47	205843.62
Maximum price / bdt of wood fuel delivered =		-183.65		-208.14		-223.44

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

CASE 1.1 ABCO PLASTICS DIVISION

INPUT DATA & BASIC ASSUMPTIONS

1. Plant cost		
1a	200000	
1b	200000	
1c	200000	
2. Plant size (MJ/hr)	7062	
3. Existing oil use/year (l)	264000	
4. $/l oil	.314	
5. Current oil costs ($/yr)	82896	
6. Extra labour costs ($/yr)	0	
7. % Mtnc costs	5	
7.1 Extra maintenance costs ($/yr)		
1a	10000	
1b	10000	
1c	10000	
8. % oil use	10	
8.1 Future oil use ($/yr)	8289.6	
9. DEMO GRANT		
1a		100000
1b		100000
1c		100000
10. Net plant cost ($)		
1a		100000
1b		100000
1c		100000
11. Required IRR		.2
12. # yrs plant life (n)		20
13. Plant salvage value @ n yrs,% & $		10
1a		20000
1b		20000
1c		20000
14. PVIF(a)IRR n		4.869579734
15. NPV,yr n,IRR		.0260840533
16. Tax rate		.5
		.5

	CASE 1a	CASE 1b	CASE 1c
17. % oil combus	.8	.8	.8
18. Heat content oil (j/l)	38700000	38700000	38700000
19. % wood subs	.9	.9	.9
20. Heat content wood (j/t)	20000000000	20000000000	20000000000
21. % wood combustion@% H2o	.6	.68	.73
22. %H2O in wood	.44	.3	.1
23. Wood fuel required (bdt/yr)	613.01	540.89	503.84

Calculate maximum cost of wood fuel ; given above criteria

	CASE 1a WOOD @ 44%MC Debit	Credit	CASE 1b WOOD @30%MC Debit	Credit	CASE 1c WOOD @ 10%MC Debit	Credit
1.Plant cost	100000.00		100000.00		100000.00	
2.Fuel saving		181650.91		181650.91		181650.91
3.P.V. maintenance	24347.90		24347.90		24347.90	
4.P.V. CCA		25000.00		25000.00		25000.00
5.P.V. salvage		521.68		521.68		521.68
6.P.V. loss on salvage CCA	130.42		130.42		130.42	
7.P.V. extra labour	0		0		0	
	124478.32	207172.59	124478.32	207172.59	124478.32	207172.59
Maximum price / bdt of wood fuel delivered =		55.40		62.79		67.41

SITE2.1

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

CASE 2.1 SUNSET HOME MODIFIED PLANT

INPUT DATA & BASIC ASSUMPTIONS

1. Plant cost		9. DEMO GRANT			CASE 1a	CASE 1b	CASE 1c
1a	140000	1a	100000	17. % oil combus	.75	.75	.75
1b	140000	1b	100000				
1c	140000	1c	100000				
2. Plant size (MJ/hr)	3531	10. Net plant cost ($)		18. Heat content oil (j/l)	38700000	38700000	38700000
		1a	40000				
		1b	40000				
3. Existing oil use/year (l)	212000	1c	40000	19. % wood subs	.9	.9	.9
		11. Required IRR	.15				
4. $/l oil	.293	12. # yrs plant life (n)	20	20. Heat content wood (j/t)	20000000000	20000000000	20000000000
5. Current oil costs ($/yr)	62116	13. Plant salvage value @ n yrs,% & $	10	21. % wood combustion@% H2o	.6	.68	.73
6. Extra labour costs ($/yr)	0	1a	14000	22. %H2O in wood	.44	.3	.1
		1b	14000				
		1c	14000				
7. % Mtnc costs	15	14. PVIF(a)IRR n	6.259331475	23. Wood fuel required (bdt/yr)	461.50	407.20	379.31
7.1 Extra maintenance costs ($/yr)		15. NPV,yr n,IRR	.0611002789				
1a	21000						
1b	21000						
1c	21000	16. Tax rate	.5				
8. % oil use	10		.5				
8.1 Future oil use ($/yr)	6211.6						

Calculate maximum cost of wood fuel ; given above criteria

	CASE 1a WOOD @ 44%MC		CASE 1b WOOD @ 30%MC		CASE 1c WOOD @ 10%MC	
	Debit	Credit	Debit	Credit	Debit	Credit
1.Plant cost	40000.00		40000.00		40000.00	
2.Fuel saving		174962.09		174962.09		174962.09
3.P.V. maintenance	65722.98		65722.98		65722.98	
4.P.V. CCA		11428.57		11428.57		11428.57
5.P.V. salvage		855.40		855.40		855.40
6.P.V. loss on salvage CCA	244.40		244.40		244.40	
7.P.V. extra labour	0		0		0	
	105967.38	187246.06	105967.38	187246.06	105967.38	187246.06
Maximum price / bdt of wood fuel delivered =		56.27		63.78		68.47

APPENDIX 6
OBSERVATIONS, CONVERSION FACTORS, AND GLOSSARY OF TERMS

Appendix 6

1. Abbreviations

bbl	= barrels
BDt	= bone dry tonne
ha	= hectare
J	= joule
l	= litre
M.C.	= moisture content
MFBM	= thousand board foot measure
N/A	= data not available

2. Prefixes

k — kilo	10^3
M — Mega	10^6
G — Giga	10^9
T — Tera	10^{12}

3. Conversion Factors

3.1 Length, Area, Volume, Mass

1 barrel	158.91 litres
1 bone dry tonne (wood)	2.0 tonnes (green condition)
1 cunit (wood)	100 cubic feet of solid wood
1 cunit (wood)	2.83 cubic meters
1 hectare	2.47 acres
1 tonne (metric)	1.1023 ton (short)
1 tonne (metric)	2205 pounds
1 tonne (metric)	1000 kilograms
1 cubic meter of wood	0.4 bone dry tonnes

3.2 Energy

1 barrel (furnace oil)	6.15×10^9 Joules
1 bone dry tonne (wood)	20.0×10^9 Joules
1 litre (furnace oil)	38.7×10^6 Joules
1 litre (furnace oil)	0.00258 bone dry tonnes of wood at efficiencies of 80% for oil and 60% for wood at 50% moisture content.

3.3 Sawmill Residues

1000 FBM	yields	1.1 bone dry tonnes of chips
1000 FBM	yields	0.4 bone dry tonnes of sawdust
1000 FBM	yields	0.45 bone dry tonnes of bark
1000 FBM	yields	0.25 bone dry tonnes of shavings

Note: these are average conversion factors. Actual conversion factors will vary with each sawmill depending on the equipment in the mill and the type of products produced.

4. Glossary of Terms

Bone Dry - wood having zero moisture content. See oven dry also.

Cord - a common measure of firewood and pulpwood equal to the volume of wood in round (not split or chipped) form that can be neatly stacked, with the individual pieces parallel to one another, in a pile 4 feet wide, 4 feet high and 8 feet long. The pile volume is 128 cubic feet, but due to air spaces between the pieces, the actual solid wood volume is about 85 cubic feet.

Efficiency or Appliance Efficiency - the percentage or fraction of the chemical energy in the fuel actually converted to useful heat by the furnace or boiler.

Forwarder - a rugged, four-wheel drive, forestry machine able to travel off road and used to transport trees from the felling area to roadside by carrying them clear of the ground on a flat bed or bunker.

Full Tree Length - tree complete with crown and branches removed from forest in one piece.

Fungi - a group of plants including mildews and molds that have no leaves, flowers or green colour and reproduce by means of spores.

Green Wood or Chips - undried, freshly cut wood or chips from a live tree.

Load Factor - the average output of a heating plant divided by the peak or maximum output of the heating plant. For example:

$$\text{Load Factor} = \frac{\text{(Total yearly heat output)}}{\text{(Operating hours per year)} \times \text{Peak hourly heat output}}$$

Moisture Content (MC) - the fraction or percentage of water in wood as determined in a laboratory drying oven and calculated on either a dry or a wet basis. A wet basis moisture content is used in this report.

$$\text{MC(dry basis)} = \frac{\text{weight of water removed in oven drying}}{\text{oven dry weight of wood}} \times 100$$

$$\text{MC(wet basis)} = \frac{\text{weight of water removed in oven drying}}{\text{original weight of wood including its moisture}} \times 100$$

Ovendry Wood	- wood dried to constant weight at about 105°C and low humidity. By definition, wood with zero moisture content. Also called bone dry.
Pulp Wood	- a piece of wood 4 ft. or 8 ft. long to be used to produce woodpulp. Also called pulpstick.
Seasoned Wood	- wood which has lost a significant amount of its original (green) moisture. There is no universally accepted definition of the moisture content of such wood.
Skidder	- a rugged, articulated, four-wheel drive off-road forestry tractor equipped to permit it to drag or skid trees from the felling area to roadside or to a landing using a grapple or cables.
Thinning, Pre-commercial	- removal of small trees with no conventional commercial value to improve growth of remaining trees.
Thinning, Commercial	- removal of trees large enough to be sold as pulpwood or fuel wood to improve growth of remaining stand.
Tree Length	- tree, with crown and branches removed, removed from forest in one piece.
Winch	- a device using a wire rope around a mechanically driven drum and attached to a skidder or farm tractor to enable trees or bundles of trees to be dragged from the felling site to roadside.

APPENDIX 7
VARIOUS METHODS OF HARVEST ON SMALL WOODLOTS

(Reproduced with the kind permission of Dr. S. M. Pneumatico from the report by J. Hermelin, M. H. Schneider, and C. A. Short)

System 1: Fully Manual

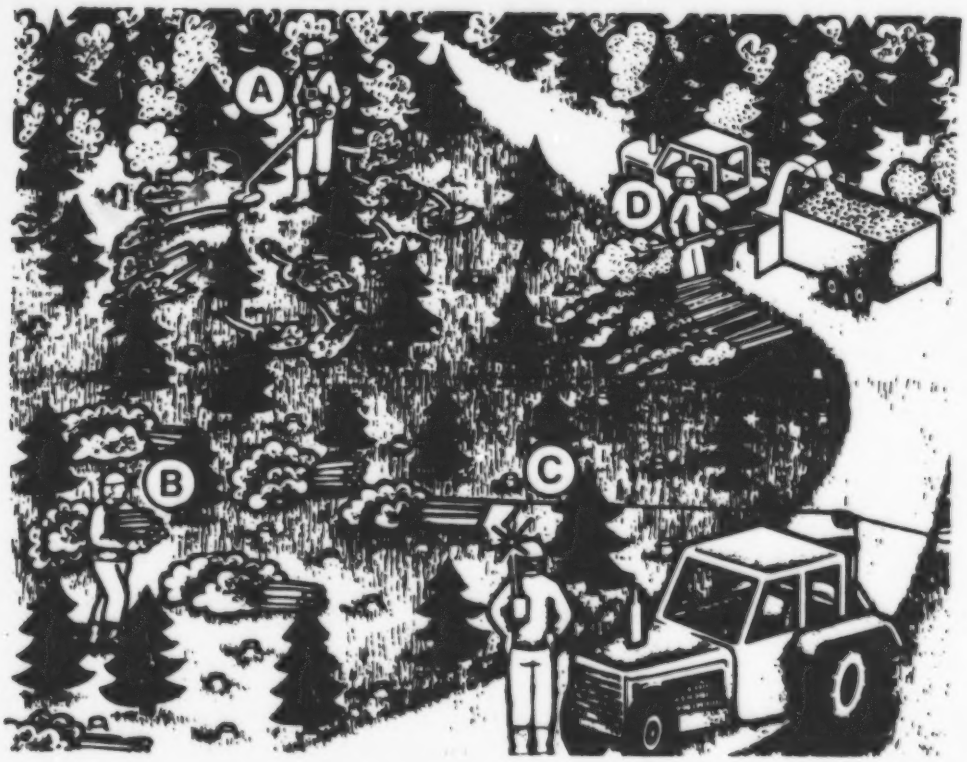
This system requires tractor trails to be laid out 30 - 40 metres (100 - 130 feet) apart. Chipping takes place along the tractor trails. The cleaning saw operator fells the trees using directional felling while another worker manually brings the trees to the trail side. The chipper operator feeds the trees, butt first, into the chipper.

Manual Harvesting System

A. Pre-commercial thinning with a clearing saw and using directed felling.
B. Manual bunching of trees with butts facing the tractor trail. Note that the bunches should be perpendicular to the feeder opening on the chipper.
C. Chipping and transporting of the chips to the consumer.

System 2: Manual with Logging Winch

This system requires tractor trails to be laid out 40 - 60 metres (130 - 200 feet) apart. Chipping takes place along the tractor trails. The cleaning saw operator fells the trees using directional felling and another worker brings the trees together in bunches. These bunches are then winched to the trail using a skidpan and a light winch with radio or manual remote control. The chipper operator feeds the trees, butt first, into the chipper.



Manual Harvesting Using a Winch

A. Pre-commercial thinning with a clearing saw and using directed felling.
B. Manual bunching in the stand with butts facing the tractor trail.
C. Winching of bunches to tractor trail using a skid pan. The cone shaped skid pan reduces friction and the chances for the load to get stuck.
D. Chipping and transporting of chips to the consumer.

System 3: Manual with Winch and Forwarder

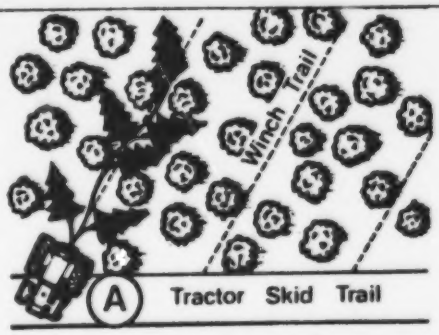
This system requires tractor trails to be laid out 40 - 60 metres (130 - 200 feet) apart. Chipping is done along a road, on a landing or at the place of consumption. The cleaning saw operator fells the trees using directional felling while another worker brings the trees together in bunches with the butts facing the tractor trail. The tractor operator brings the bunches to the trail and loads them on his trailer using a wire crane loader with remote manual or radio control. The loaded trailer is then brought to a road, landing or the point of consumption where the trees are unloaded and chipped.

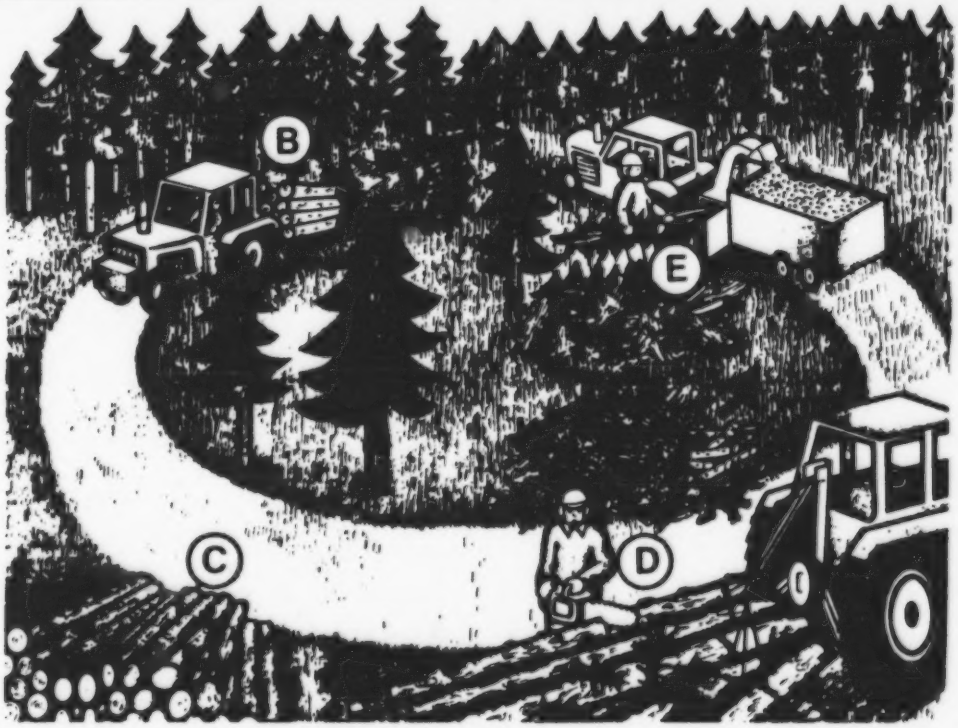
Manual Harvesting with Winch and Forwarder

A. Pre-commercial thinning with a clearing saw and using directed felling.
B. Manual bunching in the stand with butts facing the tractor trail.
C. Winching of bunches to trail and loading of bunches on a light trailer using a wire crane loader and a skid pan. The cone shaped skid pan reduces friction and the chances for the load to get stuck. The load on the trailer is then transported to a road or a landing or the place of consumption.
D. Chipping at roadside or landing or place of consumption.

System 1: Whole Tree

This system requires a distance of 30 - 60 metres (100 - 200 feet) between tractor skid trails. The trees are felled away from the tractor trail, that is, with the butts towards the winch trail. The winch trails are laid out in a herring bone pattern at an angle of about 45° to the tractor trail. The tractor is positioned at the end of the winch trail. The main line wire is pulled out and the trees are attached to it using chokers. The trees are then winched to the tractor which skids then to a landing area. Here the branches are removed and small sawlogs and pulpwood are cut off. The branches and the tops are then chipped. The whole tree, complete with branches and tops, is taken out. This method is often called a "whole tree logging system".





Whole Tree Harvesting

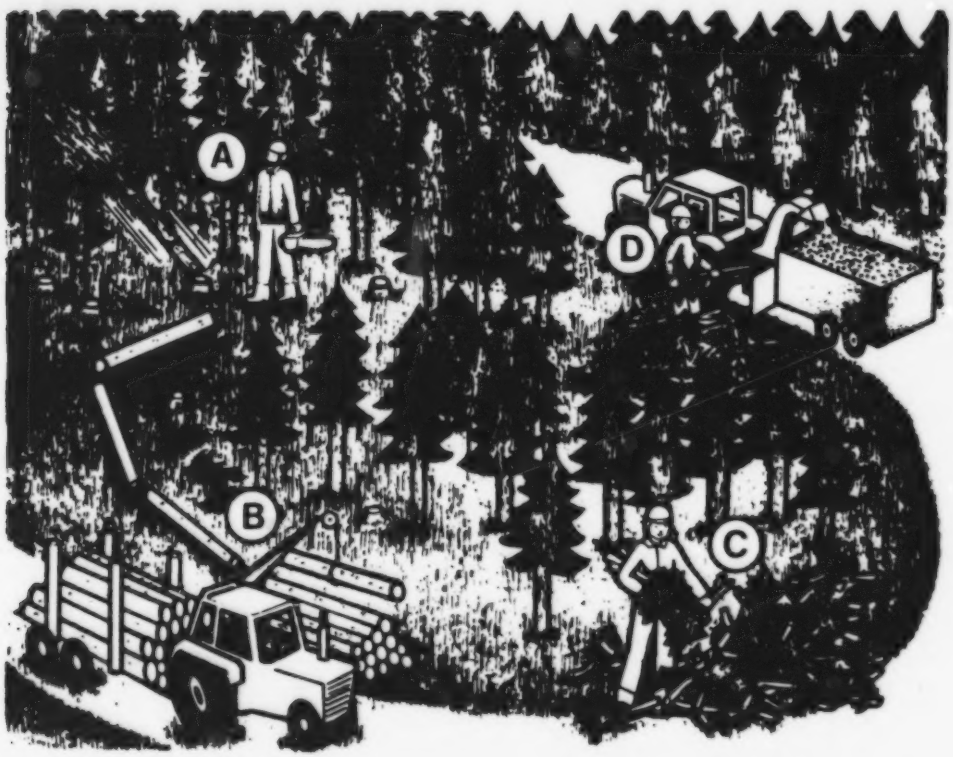
A. Directed felling with the individual tree aligned in a herring bone pattern along the winch trail. These trees are then attached to the winch line using chokers.
B. Trees are winched to the tractor.
C. The load of trees is transported (skidded) out to the landing.
D. Limbs and tops are removed and small sawlogs and pulpwood are cut off.
E. Tops and branches are chipped.

System 2: Shortwood/Winch

This system requires that the tractor trails be laid out 30 - 60 metres (100 - 200 feet) apart. The trees are felled towards the trail in a herring bone pattern. The limbs and tops are removed. The small sawlogs and pulp sticks are cut off and bunched along a winch trail.

The logs and pulpwood are winched out and loaded on a trailer using a wire crane loader. The tops and branches are carried out manually to the trailside and then chipped. The load of logs and pulpwood is taken out to a truck road.

This is called a shortwood logging system since logs and pulpwood are produced in the stand and winched out.



Shortwood Harvesting with a Winch

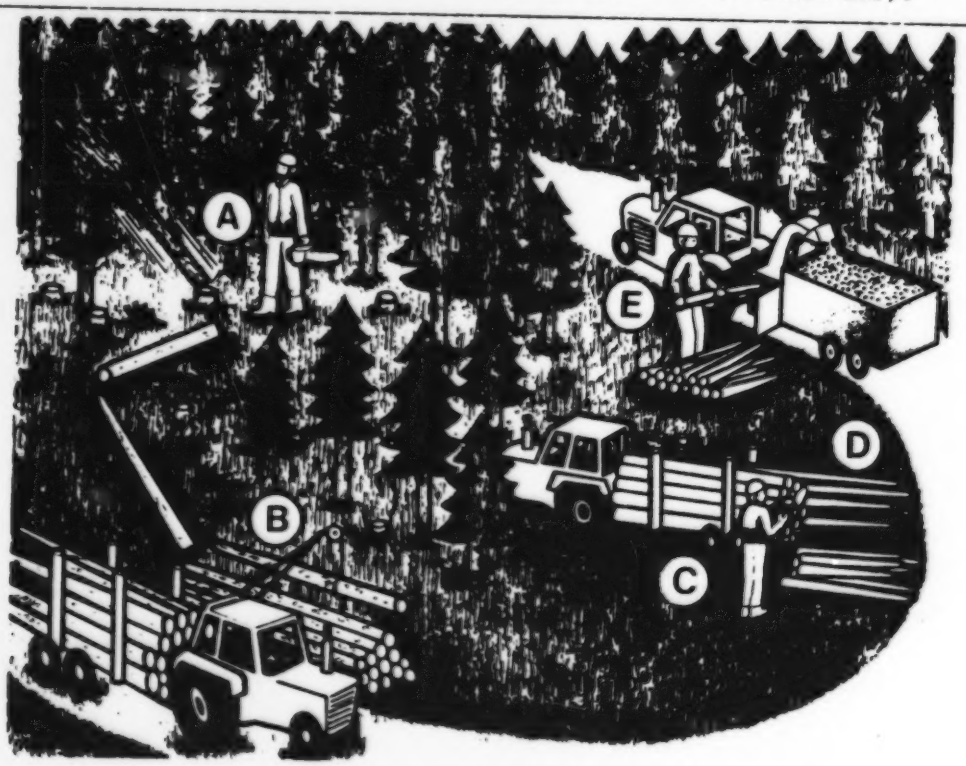
A. Trees are felled, branched and bucked and the products bunched along the winch trail.
B. The sawlogs and pulpwood are both winched out and loaded on the trailer using a wire crane loader.
C. Tops and branches are manually carried out to the tractor trail.
D. Tops and branches are chipped.

System 3: Shortwood/Tree-length

This system requires tractor trails to be laid out 30 - 60 metres (100 - 200 feet) apart. The trees are felled towards the trail in a herring bone pattern. The limbs are removed but the top is not cut off. The small sawlogs and pulp sticks are cut off except for the last piece which is left with the top. The material is then bunched.

The sawlogs, pulpwood and the pieces containing the tops are winched out and loaded on a trailer using a wire crane loader. The load is taken out to a landing where the tops are cut off with a chainsaw directly on the loaded trailer. The tops are then chipped.

This method is a mixture of a shortwood (logs and pulpwood) and a tree length/segment system (a section of the tree is taken out).



Shortwood/Tree Length Harvesting

A. Trees are felled, branched and bunched along the winch trail - the tops are not cut off.
B. The sawlogs, pulpwood and pulpwood with the tops attached are winched out and loaded on the trailer with a wire crane loader.
C. At the landing the tops are cut off and chipped.
D. Cutting off the tops.
E. Chipping of tops.

System 4: Full Tree

This system requires tractor trails to be laid out 30 - 60 metres (100 - 200 feet) apart. The trees are felled away from and perpendicular to the tractor trail. No limbing or bucking takes place. Trees are bunched along the winch trail where this is possible. The bunches are winched to the trailside and chipped.

This is a full tree logging system (the whole tree is extracted). It is only suitable for small dimension stands where it is not economical to take out small pulpwood. The limiting factor is the capacity of the chipper.

If the trees are large, they can be cut into irregular-length sections. This is called a "tree segment logging system".

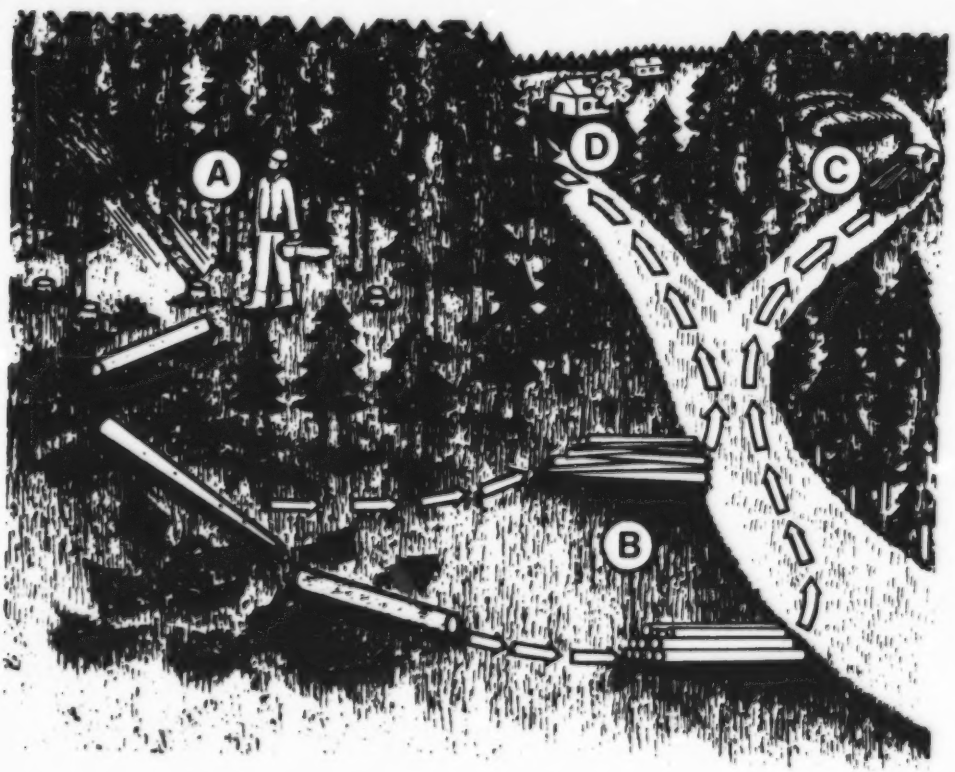
Full Tree Harvesting

A. Directed felling of trees away from the tractor trail and bunching where it is possible.
B. Winching out bunches to tractor trail.
C. Chipping of the whole tree or tree segment (pulpwood is not taken out).

System 5: Shortwood/Forwarder

This system requires tractor trails to be laid out 15 - 30 metres (50 - 100 feet) apart. The trees are felled towards the trail. Smaller sawlogs, pulpwood and tops are cut off and manually bunched along the tractor trail. A standard forwarder picks up the logs and pulp sticks and takes them to roadside or landing. The tops are then separately transported to the consumer and chipped.

This is a shortwood logging system because sawlogs, pulpwood, and tops are taken out. The off-road transport in this system is done with a big standard forwarder using a knuckle boom grapple loader.



Shortwood Harvesting

A. Trees are felled, branched and bucked. The products are manually separated and bunched in a zone along the trail where the tractor operator can reach them.
B. Transportation of products to landing (sawlogs, pulpwood) and tops to landing, roadside or consumer for chipping.
C. Sawlog and pulpwood brought to landing.
D. Tops to be chipped or transported to chipper.

System 6: Tree Length

This system requires tractor trails to be laid out 30 - 60 metres (100 - 200 feet) apart. The trees are felled away from the trail. No limbs or tops are removed. The felled trees are winched to the tractor trail and pass through a "wrap around" limbing device attached to a stump. The limbed stems are then cut into sawlogs and pulpwood and the tops and branches are chipped.

The use of a limbing device in combination with a winch limbs the trees as well as piles the branches along the trail ready for chipping. The limbed stems can also be transported to a landing by a grapple skidder, clam bunk skidder or a forwarder and cut up on the landing.

Tree Length Harvesting

A. Directed felling of trees away from the tractor trail.
B. Winching the tree to the trail through a limbing device fastened on a stump.
C. The limbed stems can be cut up on the spot or transported to a landing for processing.
D. Chipping of logging residues.